AN INVESTIGATION OF THE SKILL LEVEL THAT LEARNERS DEMONSTRATE WHEN ANSWERING QUESTIONS ON PROPORTIONAL RELATIONSHIPS IN GRADE 5 AT KHWEZI PRIMARY SCHOOL, PIETERMARITZBURG AND THE STRATEGIES THAT THESE LEARNERS USE IN SOLVING PROPORTIONAL PROBLEMS.

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ABSTRACT

The original aim of this study was to assess the effectiveness of a teaching approach based on the Means of Assisting Performance (MAP) by Tharp and Gallimore (1988) in the teaching of science to Grade 5 (Standard three) level. The basic method was to compare performance of three Grade 5 classes using pre-test and post-test. One class (Grade 5A) was taught for three weeks using an intervention programme which was based on the MAP teaching approach. A second class (Grade 5B), received a teaching approach which was based on a "traditional teaching" technique. Both classes were taught by the researcher.

A 3rd class (Grade 5C) was not taught by the researcher and this class was included in order to measure test effect. The information obtained from these tests was supplemented by qualitative observation of the pupils at work, interviews with teachers and pupils at the school. A general science topic (soil) was chosen with a focus on proportional reasoning skills. Because of the difficulties which arose, the study concentrated on investigating the skill level which learners demonstrated when answering questions on proportional relationships in Grade 5 at Khwezi Primary, and looking at strategies that learners at this level of development use in solving proportional problems.

The results obtained in this study suggest the following.

(i) Learners tested in this study showed a low-level use of the intuitive skills which are needed in laying the necessary foundation for the development of advanced proportional reasoning abilities.

(ii) The strategies which were used by the learners tested were those referred to as incomplete, qualitative, and additive strategies as well as guessing.

(iii) Strategies used by the learners tested in this study were similar to the strategies used by similar learners tested by other researchers in other parts of the world.

The intervention was short, and no substantial gains in the skill of proportional relationships were observed. The teaching methodology based on MAP brought about changes to the learning styles of the learners. Learners were not just recipients of information but were active role players in the learning process.

DECLARATION

I hereby declare that this dissertation, unless stated otherwise, is my own original work.

Dennis Sibongiseni Memela

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ABBREVIATION AND TERMINOLOGY

The following abbreviations are used in the text.

APU	Assessment of Performance Unit
CEPD	Centre for Education Policy Development
COST	Classroom Observation of Science Teaching
DET	Department of Education and Training
MAP	Means of Assisting Performance
NDE	National Department of Education
NQF	National Qualification Framework
OBE	Outcomes Based Education
SAQA	South African Qualifications Authority
STOS	Science Teaching Observation Schedule
ZPD	Zone of Proximal Development

TABLE OF CONTENTS

CHAPTER FOUR:

CHAPTER FIVE: ANALYSIS AND DISCUSSION OF DATA

STRUCTURE OF THIS DISSERTATION

The initial aim of doing this study was to assess the effectiveness of the Means of Assisting Performance based approach to teaching. This was to be done using a quasi-experimental method of investigation. Because of the problems which arose during the course of the investigation, a new approach to the study was adopted. As a result, the study focused on an investigation of the skill level which learners demonstrated when answering questions on proportional relationships together with the strategies used by these learners at Grade 5 level in solving problems on proportion.

The first chapter looks at the nature of science education in South Africa with special reference to 'Black' education. It also looks at the global transformation of primary education from content-based to process-based and ultimately to the phase of conflating the two approaches. The chapter closes by looking at the initial aims of the study, why they were not accomplished and what were the subsequent aims of the study.

The second chapter analyses the impact of three cognitive development theories and their influence on teaching. These theories are: Piaget's theory of cognitive development; Vygotskian theory of cognitive development, and Information Processing Theory. The reasons for choosing a Vygotskian framework for the intervention reported in this study are also given. The work done by other researchers on proportion is also referred to here in order to provide the necessary background for this research work.

Chapter three deals with the methods which were used in doing this study. Problems encountered during the course of the investigation are highlighted, as well as how these problems led to the invalidation of some data. A change of emphasis was then followed in the analyses of data. This chapter also gives information on who was involved in this study, where it was done and the developmental level of the pupils used in the study.

Chapter four discusses the lessons which were presented in the two approaches involved in this investigation. One form of lesson presentation was based on the Means of Assisting Performance as developed by Tharp and Gallimore (1988: 47-69) and the second method of presentation was based on "traditional teaching" using a style which was informed by the lessons which were observed by the researcher at the beginning of this investigation. These two approaches were used to teach different groups. This chapter explains the general characteristics of each teaching approach used in the lessons which were taught during the teaching phase.

In chapter five the data gathered is discussed and analysed. It looks at how learners solved proportional problems, the level of skill development and the strategies used by learners. It also looks at whether the strategies were unique or showed similar trends to those seen elsewhere.

The last chapter provides the conclusion of this study. It gives a summary of the results obtained, discusses the limitations of the study, makes suggestions for further study and the implications for teaching.

CHAPTER ONE : INTRODUCTION

1.1 INTRODUCTION

This chapter traces the nature of teaching strategies that have been used by teachers in educating learners from disadvantaged schools. It provides a backdrop against which education in disadvantaged communities should be viewed. It also draws some comparison, albeit on a small scale, with global trends in primary education. Although South Africa has a unique set of circumstances, it cannot be divorced from current debate and contestations prevailing in primary science.

Harlen (1992) states that primary science is relatively young compared to science education, as a result, there is not a great volume of research and tradition of scholarship. This neglect is a pity, since the first eight years of schooling are not only in quantity a highly significant proportion of children's education but these years have perhaps an even greater significance in occupying the formative period when a foundation of basic skills, concepts and attitudes is created (Mcdonald 1993: 88). It is this neglect of research, referred to by Harlen, which is making it difficult for science educators in South Africa to elevate the standard of science education in this country. The role of primary education as the necessary foundation for secondary education is also highlighted in this chapter. The chapter closes by looking at the key research questions that the study attempts to address.

1.2 THE QUALITY OF TEACHING IN SOUTH AFRICA

The education which is provided to the masses of the people in South Africa under the new democratic government is being emasculated by the same problems which were endemic under the old government. These problems include: huge classes of up to 100 learners; under-qualified and unqualified teachers; teachers not seeing themselves as part of the problem; archaic methods of teaching; lack of supervision of learners on the part of the teachers and a massive rise in numbers which naturally affects quality (Kahn and Rollnick, 1993: 267). Any discussion of what is going on in schools should be seen against the backdrop of these problems.

The problems engulfing the education system in South Africa in the long run may virtually cripple the major objectives of the national government, of reducing massive unemployment and bringing about high economic growth. It is also true in this country that there exists a shortage of skilled manpower and Blacks are grossly under-represented in technical and other scientific fields. This surely calls for more science oriented learning to be undertaken in our schools. The long-term technical skilled person-needs have been assessed to be far in excess of the output of the present system (see Kraak, 1989). A massive output of scientifically skilled school leavers is needed in this country. Kahn and Rollnick (1993) argued that the required output of scientifically skilled school leavers will not be realised unless science education takes cognisance of the contextual reality of the people it is supposed to serve, that is to say, it becomes relevant to them (p.268).

Kahn and Rollnick (1993) wrote that, teaching in most of our schools is flawed in that it is largely characterised by rote-learning which is institutionalized in this country and is not seen to prepare learners for independent problem solving skills (p.268). Muller (1987), in his study of different schools found that, rote-learning not only occurs in black schools but occurs across the racial divide. He states that, "*where I set out to seek differences I found similarities*" (p.112). Rote learning is also associated with authoritarian teacher-centred approaches to instruction which mostly stifle learner involvement and engagement with the learning material.

The authoritarian model, which places the teacher as the main source of knowledge, is prevalent in most schools today. In this approach teaching is known to be a one way process where teachers simply give information to learners to be learned and memorised. School science courses need to de-emphasise teacher-dominated lessons in favour of more active modes of learning. Teachers must not be seen to be the sole providers of knowledge and learners mere passive recipients of information. These characteristics of the type of teaching going on in our schools presently seem to parallel the kind of teaching Yager (1983) identified as resulting in the crisis existing in American science education in the late seventies and early eighties. He described it as follows,

> *" nearly all science teachers presented science via lectures and/or question and answer techniques; over 90 per cent of the science teachers viewed their goals for teaching in connection with specific content; and over 90 per cent of all science teachers used a textbook 95 per cent of the time"* (p.155).

Research carried out in the USA under the auspices of the Search for Excellence in Science Teaching programme (see Kyle, Bonnstetter, Gadsen and Shymansky, 1988) has identified four factors which characterise excellent teaching. These researchers argue that, the content should relate to children's personal needs (child-centred, societal issues, academic preparation and career education). In his discussion of science teaching Munting (1991) points out that,

> *" if there is a pressing need to increase the number of school leavers choosing careers in the sciences, teaching must be of such a quality that by the time children reach Std 7, when subject choices for matriculation need to be made, they should be interested enough and obtain sufficient marks to make it desirable for them to continue with physical science or mathematics"* (154-155).

It is evident that without the knowledge of these subjects, due to uninspiring teaching, many careers in the sciences are closed to learners. Stimulating teaching must obtain in the primary schools and the main goal of science teaching at primary level should be to develop and maintain a high level of interest in the learners (HSRC,1981:8; National Science Board, 1983:13). Research on science teaching seems to indicate that attitudes of children towards science appear to be formed earlier than for other subjects: children tend to have adopted a definite position with regards to their like or dislike of the subject by the time they reach high school (see Kelly, 1959; Duckworth, 1972). Although Kelly and Duckworth were reporting findings outside South Africa, similar trends seem to be found here also.

Munting (1991) also argued that to participate meaningfully in a democratic society during the 21st century, every member needs to have some insight into major scientific concepts, how information is gathered, ideas tested, evidence evaluated and problems solved (p.152). For our learners to be able to do all these things, they need to be introduced to a type of education which will ensure that both knowledge and skills are provided to the learners at a primary school level.

Investigations should play a major role in science education and a growing body of research seems to suggest that teaching should be inquiry-based and should follow a process approach (see Bredderman, 1983; Kyle and Bonnstetter, 1987; Shymansky, Kyle and Alport, 1983). This patently points to the need for practical work by children, individually or in groups. Stor-Hunt (1996) found that students who experienced hands-on activities frequently out-performed those who did not have frequent hands-on experience (p.103). Learners at primary level should be exposed to a lot of practical work in order to develop the skills of doing things for themselves. In relation to this Tobin (1988) makes the important point that active learning of high cognitive level skills necessitates active teaching (p.25). One group structure will not always be suitable for all learners and all tasks. A blend is needed of whole class, small groups and individualized activities at appropriate times so that active student learning can take place for all learners.

Hodson (1990) also provides a challenging comment when he points out that, most of our schools do practicals unproductively and are unable to justify the most extravagant claims made for it (p.36). In many situations, what teachers regard as practical is just "recipe following". Yager (1983) who was working in the USA, described a similar situation in which practicals were largely a verification of what students had been told in class or what they had read in books. He also pointed out that inquiry-based experiments were not carried out in schools and this led him to bewail the fact that,

> *"school science actually is a detriment to the production of scientifically literate persons.....students like science less the longer they are in school. The study of science is viewed as less exciting as students progress from elementary to middle / junior high to high school"* (p.155).

Since the style of laboratory work provided seems to influence the learning outcomes relative to learning scientific concepts, we need to look at what children are doing in the laboratory in order to see the pedagogical value of practical work.

The 'content approach', a form of teaching which puts more emphasis on knowledge than skills, is disempowering in that it brings in the element of objectivity in science which insulated science from any social context (see Jenkins, 1985). This is based on the notion that there exists a knowledge reality outside of human perceptions. The alternative approach as seen by Millar (1989) is looking at processes, not as organizing elements but as a major part of what is to be learnt (p.48). Screen (1986) however described processes as,

> *"the sequences of events which are engaged when researchers take part in a scientific investigation. They seem to build into a hierarchy, at least initially, though once entered into the whole becomes cyclical. These processes build up an intellectual framework for problem solving" (p.14).*

The process approach puts less emphasis on content because of a belief that concepts would be incidentally learned. The process approach does have flaws in that it looks at processes as ends rather than means to an end. Driver et al. (1984) however assume a stance on teaching and learning which supersedes the conventional dichotomy of content and process (p.79).

There is definitely a crisis in the South African education system if less than 10% of learners do science at matric level, and yet teachers still use archaic teaching methods. Davis et al. (1993) write that this current crisis in education should be viewed with optimism, and is an essential element of a change process (p.627). A crisis in a field of activity is an indication that the existing approach is under scrutiny and being challenged. In this situation it is the responsibility of the of the educators to re-examine and reconceptualize their views on teaching and learning.

1.3 THE PURPOSE OF THIS STUDY

This study was conducted in Pietermaritzburg at a primary (ex D.E.T.) school.

The initial question that the study tried to address was: To what extent would a teaching approach based on the Means of Assisting Performance by Tharp and Gallimore (1988) be effective in the classroom? A quasi-experimental approach was to be used in order to determine the effectiveness of the teaching approach. Because of what transpired during the course of the investigation and the problems which were experienced on the ground, the main aim of the study was changed. The revised main aim of the study was: an investigation into the skill level of learners in answering questions on proportional relationships, and an analysis of the strategies used by learners at grade 5 level in solving proportional problems.

The research questions guiding this study are:

1. What is the level of performance on proportional reasoning skill at Grade 5 level?
2. What strategies are used by learners at Grade 5 level when they attempt to solve proportional problems?
3. To what extent would a teaching approach based on the Means of Assisting Performance by Tharp and Gallimore (1988) be effective in the classroom (grade 5 level)?

The theoretical framework underpinning this study is discussed in the next chapter. The theoretical viewpoints which inform the approach that is used in this study are discussed including Piaget's cognitive development theory, the

information processing approach, and Vygotskian cognitive development theory.

CHAPTER TWO: THEORETICAL BACKGROUND

2.1 INTRODUCTION

In this chapter the theoretical underpinnings of this work are discussed. Theories of cognitive development are fundamental in the study of skill acquisition and development. They provide a range of views and understandings regarding the study of cognition. Three important schools of thought will be discussed here: (i) Vygotskian theory of cognitive development, (ii) Piagetian theory of cognitive development, and (iii) Information-Processing theory. The reasons for choosing a Vygotskian framework are discussed together with an analysis of the Means of Assisting Performance. Theory behind the approaches used here in gathering data is also looked at.

2.2 VYGOTSKIAN MODEL OF COGNITIVE DEVELOPMENT

Vygotsky argued that human mental abilities are products of social interaction and social experiences. In his socio-historical development theory in which he differentiates human behaviour from that of other animal species, he argues that cognitive abilities and capacities are formed and built up within social phenomena; they are public and intersubjective, created through interaction with the social environment (Meadows, 1993, p.236).

Vygotsky argues that any function in the learner's cultural development appears twice: first it appears on the social plane, that is, between people as an interpsychological phenomenon, and later on the psychological plane, within the learner as an intrapsychological phenomenon (Wertch, 1981:113). The process by which the social becomes the psychological is called internalization. Internalization transforms the social process into the psychological and thereby changes its structure and functions. This is part of the construction of consciousness through human social interaction where the learner takes on self-consciousness and self-concept through social experiences. Cognitive consciousness and cognitive experiences arise socially. Individual consciousness, therefore, arises from the actions and speech of others (see Tharp & Gallimore, 1988).

The primacy of the social world in cognitive development is being emphasised here. The learner has to be assisted to transform, internalize, and use routines, ideas and skills learned socially from adults. For the learners to learn well from adults and capable peers, they should be able to observe, imitate, generalize and decontextualize in order to be able to internalize. All these skills develop under the fostering support of social interaction. To enhance learner motivation to learn, Brophy (cited in Tobin 1988) argues that teachers should provide opportunities for learners to interact with peers and to overtly engage in academic tasks.

According to Vygotsky language is important in mediating thought and is basic to its development. Speech within social interaction plays a decisive role in the formation of mental process and in the re-organization of mental processes. The development of awareness through the use of language propels thinking forward towards conceptual understanding, so that change in the understanding of words cannot be separated from conceptual development. He argues that words form means through which thought is formed and reified.

Language is also seen as one of the most important of 'psychological tools', or culturally developed ways of behaving towards objects, which allows high level cognitive functioning (Meadows, 1993:246). Language is also central to an understanding of complex human behaviours. Language is also essential if learners are to be helped through their Zone of Proximal Development (ZPD) by an educator or capable peers.

2.2.1 THE ZONE OF PROXIMAL DEVELOPMENT (ZPD)

Vygotsky (1978) defines the ZPD as

> *"the distance between the actual developmental level - as determined by individual problem solving - and the level of potential development, as determined through problem solving under adult guidance or in collaboration with more capable peers" (p.86)*

The ZPD defines those functions that have not yet matured but are in the process of maturation, functions that will soon mature but are currently in an embryonic state.

Tharp and Gallimore (1988) argue that the difference between assisted performance and unassisted performance is identified as the fundamental nexus of development and learning that Vygotsky called the zone of proximal development (ZPD) (p.30) It is conventional through standard assessment to assess a learner's developmental level by his ability to solve problems unassisted. Vygotsky states that the learner's learning potential exceeds the reach of this developmental level and is to be found by assessing those additional problems that the learner can solve with assistance.

Neo-Vygotskian thinking extends the concept of ZPD into a more general statement in relation to teaching. Teaching according to this perspective is about assisting performance through the zones. Teaching is said to occur when assistance is offered at points in the ZPD at which performance requires assistance. According to Tharp & Gallimore (1988) the path through a ZPD can be seen as having four interrelated but not exclusive stages. The first stage is characterized by a preponderance of adult assistance. The nature and the intensity of the assistance is determined by the developmental level of the learner.

The learner is initially assisted through modelling since conceptualization of the task resides with the adult and the role of the learner is that of imitation. Other means of assistance like questioning, feedback and cognitive structuring are only used when the overall performance is understood by the learner. This form of assistance is referred to by Greenfield (1984) as "scaffolding" and is different from "behaviour shaping" (p.133). In scaffolding the level of difficulty in a task is held constant whilst the learner's role is simplified by graduated assistance. The adult role decreases with an increase in the participation of the learner. This is what Bruner (1993) refers to as the "hand over principle" - the learner who has been a spectator is now a participant (p.60). The task of the first stage of the ZPD according to Tharp and Gallimore (1988) is accomplished when the learner is in control of the learning process (p.36).

In the second stage of the ZPD the learner carries on without assistance from others. This is made possible by passing control to the learner, that is, there is a movement from adult instruction to self instruction. This self instruction becomes possible through the use of self directed speech which provides self-guidance. Diaz (1986) points out that self-speech is more than instrumental in skill acquisition, it is itself an aspect of cognitive development and it eventually forms the basis for writing (p.96). Self-instruction is in this way transformed into the highest forms of communication available to the literate world.

The third stage in the movement through the ZPD is characterised by the presence of self-regulation and the internalization of a skill. If at this point the learner receives assistance from any source, it would be disruptive rather than helpful. Development in performance has reached a critical stage which

Vygotsky describes as "fruits" of development. The last stage is characterized by de-automation which is brought about by environmental changes which disrupt the performance of a skill. This disruption warrants developmental processes to be recursive. Self-speech is also a form of recursive activity for restoring competence. In some cases, requesting help would be the last resort for restoring capacity. The aim here would be to reach the maximum performance as soon as possible.

Helping learners through their ZPD's should occur within the activity settings of learning. It is in these activity settings that assistance is accorded to the learner by the teacher and also by other capable learners.

2.2.2 ACTIVITY SETTINGS OF LEARNING

Activity settings of learning are situations in the classroom that maximize opportunities for co-operation and conversation with the teacher and peers (Tharp & Gallimore, 1988, p.121). There are three types of activity settings that could be utilised in the classroom for the benefit of the learners: Centre One which is the focal point of interaction in the class; independent learning centres and the whole-group learning situation.

2.2.2.1 CENTRE ONE ACTIVITY

Centre one is the focal point of teacher-learner interaction in the classroom. This occurs within a homogenous-ability group of five or six learners. Activities vary from one group to another and from day to day. The aim of instruction here can either be cognitive, developmental or linguistic depending on the group. In each group the teacher and learner are engaged in lively instructional conversation.

The characteristics of centre one activity are:

- informal mutual participation by the teacher and learners;
- instant feedback;
- volunteered speech and highly teacher-dominated pattern of discussion;
- a thematic routine which involves content drawn from learner experience, followed by text material and then establishment of relationships between the two;
- heavy reliance on questioning from various levels of cognitive operations and the responsive instruction which the teacher builds on.

During interactive teaching, centre one occupies most of the teacher's time (Tharp & Gallimore, 1988:122).

2.2.2.2 INDEPENDENT LEARNING CENTRES

The independent learning centres are heterogenous ability groups. Learners are either assigned to a centre by the teacher or each learner is at liberty to choose the centre of his/her choice. Each of the independent learning centres is a follow up to centre one and the function of these independent learning centres is to reinforce by practising the activities of that particular centre. Distant supervision of these centres by the teacher is essential.

The skills needed in independent centres vary according to culture, age of learners, nature of subject matter and the experiences of the learners. Moving through the complex schedule and remaining diligent in the centres requires responsibility from the learners. High rates of interaction characterize the learning centres which are deliberately designed to harness peer interaction. These independent centres differ from centre one in that the learners work in the part of the ZPD where moderate assistance is required and is provided by peers. Learners do not only get assistance from peers but also give assistance to others. It is through these trials at independent performance that they gain full control and become more confident in their respective skills (Tharp, Jordan et al., 1984:124).

2.2.2.3 WHOLE-GROUP LEARNING CENTRES

Whole-group learning is a form of learning which is prevalent in many classroom situations. It could be used for orienting learners and giving them instructions pertaining to the group settings. This is a situation where the teacher is engaged with the whole class at once. It is ideal for the morning and afternoon sections as a start-up and closing sessions respectively. Teachers use the whole group to direct activities, and instil the values such as co-operation among learners which are required for the successful operation of centres. Whole-group settings are problematic especially when classes are huge and successful learning rests on the shoulders of the teacher.

The patterns of assistance in the whole group are determined by age of the learners and stage in programme of the year. With younger learners, socialization is a regular part of the programme. In this setting, the teacher is the source of assistance and peer assistance rarely occurs. There is also a tendency for teachers to favour the "recitation script" since it means less work. Time is also spent on control when using this method, and the lower ability learners suffer since they receive less attention. Although whole group settings are indispensable for some tasks, exclusive use of this method denies the learner the opportunity of being assisted by, and also of assisting, others. Activity centres are locations where the different means of assistance are used to help learners through their ZPD's. These means of assistance vary and they are used to address specific aspects of learning which form an integral part of the learning process.

2.2.3 MEANS OF ASSISTING PERFORMANCE

The studies of the different means of assistance were informed by different theories and disciplines. By considering them all together and by linking the achievement of Western psychology to the neo-Vygotskian theory of development, the explanatory power of each is increased substantially (Tharp & Gallimore, 1988, p.44).

In technical societies, linguistic means of assistance appear to be dominant and in a non-technical society "observational" learning is more prevalent since adult behaviours are available for prolonged scrutiny by learners. Learners are in this sense involved in the activity settings of society. The means of assistance may be used as a basis of instruction and assistance of learners through the ZPD.

Behavioural means of assistance consist of :

- modelling,
- contingency management,
- and feeding-back.

Some means of assistance are linguistic and these include:

- instructing,
- questioning, and
- cognitive structuring.

2.2.3.1 MODELLING

Modelling is about offering behaviour for imitation. This is probably the principal mechanism by which new behaviours are initiated, at least until language maturity is reached. Forms of modelling include: peer modelling, expert modelling and demonstrations. Modelling of a skill involves guided participation. The modelled behaviour must be centrally processed by the observer prior to performance. Observers whose conceptual and verbal skills are underdeveloped are likely to benefit more from behavioural demonstrations than from verbal modelling (Bandura, 1977, p.40). Modelling also involves incidental or inferential learning where the learner observes the model's behaviour and on the basis of these observations makes inferences about beliefs, values, attitudes and personal characteristics of the model (Good & Brophy, 1978, p.120).

2.2.3.2 COGNITIVE STRUCTURING

Cognitive structuring is a linguistic means of assistance. It assists by providing explanatory and cognitive structures that organize and justify. In cognitive structuring the person assisting the learner provides a structure for thinking and acting. There are two types of structures: explanatory structure and the structure for cognitive activity. Organization through structuring should not be unilaterally formulated by the teacher, but should instead be a joint activity. This should also invoke similar instances in other situations relevant to daily experience (Tharp & Gallimore, 1988:68).

2.2.3.3 FEEDING-BACK

Feeding-back is only linguistic in that it is verbal and it is a means of assistance which occurs in interactive teaching. Providing feedback during the learning process plays a vital role in terms of its regulatory effects. Feedback regarding performance is vital and is the single most effective means of self-assistance. This has been demonstrated for virtually all problematic behaviours in which self-regulation has been studied (Watson & Tharp, 1988:54). Feeding back needs to occur within a system with a standard and there should be mechanisms for comparing performance to the standard. There are various ways of feeding back which could be employed in the classroom. These include criterion-referenced test data, achievement test data, instantaneous teacher responses to learners and worksheets.

2.2.3.4. INSTRUCTING

Instructing is specifically a linguistic means of assistance which calls for action. Instructions should not be too authoritarian when given to the learners since they provoke opposition. A measured use of instructions is important and it should be done in order to assist a particular performance (Tharp & Gallimore, 1988:56). Instructing should be included in teaching since the instructing voice of the teacher soon becomes the self-instructing voice of the learner towards achieving self-regulation.

2.2.3.5 QUESTIONING

Questioning is another linguistic means of assistance which calls for a linguistic and cognitive response. It calls for learners' creations and activates learners mentally and verbally. It gives them the required exercise in the use of logic and the process affords the teacher opportunities for feed-back. If the teachers only lecture, they will never know what the learners are thinking (Tharp & Gallimore, 1988:58). Questions are divided into the assessing type and the assisting type. There is always a preponderance of assessing questions in the recitation script. Assistance questions should trigger a mental operation that the learners would not produce alone. If teachers in the classroom create room for these types of questions, they would be creating space for themselves to provide the necessary assistance to the learners in their classrooms.

2.2.3.6 CONTINGENCY MANAGEMENT

Contingency management forms part of the behavioural means of assistance and is focussed on positive behaviour, praise and rewards. This is form of assistance should not be confused with operant conditioning (Tharp & Wertzel, 1969:51) and it cannot be used in the classroom to bring about new behaviour. Contingency management should be applied along the ZPD to reinforce positive behaviour already accomplished.

2.2.4 REASONS FOR CHOOSING A VYGOTSKIAN FRAMEWORK

The intervention programme used in this study was based on the means of assisting performance (MAP), developed by Tharp & Gallimore (1988), based on a Vygotskian perspective. The Vygotskian approach was seen to be apt for this study since Vygotsky himself was directly concerned with improving instruction. Piaget was interested in the spontaneous development of concepts rather than in concepts developed in a school context. Vygotsky's approach does not see learners as solitary in trying to make meaning, but as participants in a joint enterprise in which meaning is derived through interaction (Howe, 1996:38). Howe further argues that the context rather than the cognitive demand of a task is important in making instructional decisions. Contextualized tasks, related to learners' everyday knowledge and interests, are very important and are best considered from a Vygotskian perspective. For the past three decades, Piagetian theory has been used as a basis of what constitutes good instructional practice in elementary science. This has led to an approach in which the objective nature of learning has been elevated at the expense of subjectivity.

Context-free learning, which ignores the social and cultural environments of people, has been the norm rather than the exception.

In a Vygotskian approach the unique circumstance of people is taken into cognisance. This position is supported by Howe (1996: 42), when he writes that Vygotsky sees knowledge as developing through the appropriation of culture, and through social interaction with others. The social construction of knowledge is evident in this perspective and is one of the driving forces of this study.

Instruction must relate to the learner's existing knowledge base and then it can be broadened to enrich the store of knowledge. Instruction should also facilitate the learner's construction of new domains of knowledge that differ from the learner's prior experience. Schema activation and development together with problem solving are major instructional goals. The significant role of social forces like people and the environment need to be recognised in the learning situation. Learning does not only occur as a result of cognitive structures having been developed, it also occurs as a result of the influence of others in the learning situation.

2.3 PIAGETIAN MODEL OF COGNITIVE DEVELOPMENT

Piaget (1970) was concerned with describing what he referred to as "objectivity", namely, the process by which we gain knowledge about the world.

He viewed the purpose of intellectual growth as that of knowing reality in an objective sense. Piaget argued that cognition is an equilibrated system based on the fact that organisms need to maintain a stable internal equilibrium within the changes and uncertainties of the outside world (Meadows, 1993: 203). This assertion captures in essence the foundations of the epistemological paradigm of Piaget's work, which are: philosophical, biological and psychological.

Meadows (1993) wrote that developmental stages form the cornerstone of this theory and four stages of development are identified (p.208). The first stage is the sensori-motor stage (0-2 years) which is characterized by knowledge tied to the content of specific sensory input, this is pre-symbolic and pre-verbal. There is also the identification of self from the environment and permanence development with regards to objects. Children during this stage develop the realization that objects or persons continue to exist even when out of sight. They also start to understand that events cause other events and there is active experimentation of using new means to gain desired ends.

The pre-operational stage (2-7 years), is where logical thought begins intuitively, speech is dominated by monologue and unawareness of contradictory statements. Concepts and generalizations cannot be formed and the child is unable to form abstractions at this stage of development. Later in the stage children solve problems involving numbers, time, space etc, and start to show by their behaviour that they understand the need to solve simple problems. Children at this stage lack operational thought such as flexible reversible reasoning which allows them to conserve, classify, seriate, co-ordinate perspectives and overcome misleading perceptual impressions.

The third stage (7-11 years) is the concrete operational, where reflections begin, thought becomes independent of perceptual cues. Equilibration between accommodation and assimilation in this stage is revealed by a more extensive use of reversibility in thinking. Social competence is increased by the development of understanding of the relativity of viewpoints.

The last stage of development is the formal operational stage (11 years onwards) which is characterised by more abstract development than in the concrete operational stage. Children are less tied to content and more capable of dealing with hypothetical material. There is coherence in thinking and it is more concerned with propositions than physical properties.

In his discussion of the stages of development Piaget argues that in each stage there are structures which precede development and that cognitive development forms a single invariant sequence of stages. Meadows (1993) points out that the models given of the last two stages are queried by both logicians and psychologists and they remain controversial (p.209). Other writers argue that the rate of progress through the stages seems to vary between individuals and cultures.

Piaget's model of cognition is a process of adaptation which involves an organism and the environment. For adaptation to occur, two schemas must be involved, the child's present schema and the new schema which is to be incorporated. The taking in of the new schema (assimilation) is coupled with the re-arrangement of the two schemas (accommodation) in order to produce something which works for that particular individual (equilibration).

Piaget further states that assimilation occurs at three levels: assimilation between schemas, assimilation between sub-schemas and the totality which integrates them into a coherent whole. He also argues that cognitive conflict might arise when the processes of assimilation and accommodation are at play and this may result in disequilibrium, which is regarded as a state in which a child holds two contrasting views. This is only corrected by cognitive equilibrium which involves confirmation and negation in order to achieve a balance. The totality of knowledge, according to Piaget (1977), is constantly being differentiated into parts and integrated back again into the whole. This process is regulated by equilibration (p.220).

Cognitive growth should produce cognitive structures that permit the individual to act on the environment with greater flexibility and in more ways. Piaget refers to 'structures' as timeless, abstract, universal laws of transformation between objects or concepts, for example the mathematical system of real numbers (Meadows, 1993:205). These cognitive structures are created by intelligence in the process of adaptation to the environment.

Piagetian theory states that knowledge construction occurs at two levels: exogenous knowledge, where there is direct encounter with the physical environment and the source of knowledge is external to the learner; and endogenous knowledge based on logico-mathematical experience, where there is high mental activity which deals specifically with the accommodation of new knowledge.

The source of knowledge is the learner's thought process. Piaget says that at a very young age (4-11yrs) the above two levels of cognition are inseparable but, when older, at what Piaget refers to as the formal level of operations, the logico-mathematical reasoning of the learner is expected to assume dominance.

A number of criticisms have been levelled against this theory of conceptual development especially that it overlooks the influence of the social context. Critics take exception to the notion of progressive decentration in which the physical and the abstract level of reality are separated as the model of intellectual development. They argue that knowledge is socially constructed, and that we cannot talk of knowing without considering the historically and socially constituted self that engages in the process of knowing. They also argue that knowing is a dialectical process that takes place in specific economic, social, cultural and historical contexts (O'Loughlin, 1992, p.791).

Meadows (1993) picks up on this point when she argues that, the account of cognitive development by Piaget has been the most popular but is clearly too rigid and does not deal adequately with the influence of cognitive material or cognitive context (p.198). Piaget's theoretical models are also challenged by Bliss (1995) who sees them as being philosophical and in the process ignoring individual differences (p.140).

A major weakness in Piaget's theory is the absence of any consideration of human subjectivity in the process of the construction of knowledge. Piaget is also seen to be missing out the basis of the unity in human self-transformation and self-constitution in and through the material and social world, that is to say, in historical materialism. For the moment it is sufficient to explain that while human beings are natural and social beings, their development of scientific knowledge and of cognition generally is conditioned by their existence as social beings. Within this perspective, the history of thought is inseparable from the history of human (social) development, and cannot refer to either the individual subject alone, or the abstract epistemic subject, or, in the last instance, the biologically normed, natural subject (p.86, cited in O'Loughlin, 1992, p.800).

Buck-Morss (1975) argues that the decontextualized notion of an active learner derived from Piaget's theory is likely to be disempowering. This means that formal cognitive skills may indeed increase the learner's ability to adapt to the present society rather than to criticize or change it (p.41). Critical educators argue that abstraction is a source of mystification and oppression. They further argue that a curriculum must emerge from the generative themes of people's lives and that if education is to be empowering it must culminate in praxis (see Freire, 1970).

Learner-centred pedagogy which is the cornerstone of this type of learning is also criticized. Delpit (1988) argues that "to act as if power does not exist is to ensure that the power status quo remains the same" (p. 292). The true nature of power relations is concealed in the learner-centred classrooms. Despite the changed social arrangements in the their classrooms, learner-centred teachers possess and use an abundance of power (see Edwards and Mercer, 1987).

Language in this theory is not regarded as a *sine qua non* for development and this is paradoxical since Piaget uses clinical interviews to analyse learners' cognitive structures, a process grounded in the use of language. Language usage in this type of research is enormous and problems associated with this are huge (see Siegel, 1978). This is very true especially when considering the age of the pupils involved in the study.

2.3.1 PIAGET AND SCIENCE EDUCATION

Piaget's cognitive development theory contributed immensely towards the formulation of constructivism as a theory of learning. Development, from a constructivist point of view, precedes learning (Bliss, 1995:55). Piaget was one of the first theorists to put forward the notion that children construct their own knowledge; that this knowledge is different in kind from an adult's and that it is evolves and changes over the years (ibid., p.55). Piaget's stage theory gave educators a new way of thinking about teaching and learning. They used it as a tool to match the content of science curricula to learners' spontaneous intellectual development.

Most of Piaget's research concentrated on young learners and how they construct ideas. Descriptions of older learners are limited and his interest lay in ideas that learners could spontaneously construct rather than in how they made sense of ideas given to them in schools. Since the 1970's a trend has developed in which educators have set out to describe learners' ideas about scientific concepts. These studies revealed that learners' ideas are very different from those taught in school and that many of them are very robust and particularly resistant to alteration through teaching (see Bliss, 1995).

2.3.2 CONSTRUCTIVISM

The cornerstone of constructivism can be summarised by the statement from Ausubel that "*the most important single factor influencing learning is what the learner already knows*" (Ausubel, 1968:vi). This leads to an approach to teaching that begins with an analysis of students' pre-existing ideas which will ultimately lead to the full involvement of learners and also provide the educator with the knowledge of the input that needs to be made. The intuitive preconceptions which all children hold are of utmost importance in the learning process. These preconceptions are employed in meaningful learning experiences and they sometimes vary from culture to culture. Learners in a variety of cultures form their own alternative frameworks to explain scientific phenomena (see Gilbert & Watts, 1983). Zinchenko (1989) commented that there is no guarantee that science divorced from culture can sustain itself and that the value of a constructive approach is that it is sensitive to both science and culture (p.257). Harlen (1992), in support of this view, argues that *"children form ideas about things around them long before they are taught about them in school"* (p. 14). Practical lessons are regarded as important in testing these preconceptions. The practical lessons need to be used to challenge and test learners' ideas against reality, and offer opportunities to reinforce new concepts. For learners to change their ideas, there needs to be dissatisfaction with existing conceptions and new conceptions must appear intelligible and plausible (see Driver & Oldham, 1986).

Teaching should facilitate negotiation and interpretation based on the learner's prior knowledge. Novak (1978) pointed out that educators tend to conflate learning and presentation by assuming that presentation of any material using whatever method would guarantee learning (p.591).

The context within which a problem is set and the familiarity of the ideas to the learner will both affect the logical structures the learner will bring to the task (Driver, 1983, p. 90). The local environment is mostly used as a resource in science education. Preconceptions sometimes vary from culture to culture. Constructivism offers the opportunity to make maximum use of the environment and the learner's daily experience.

Constructivist theory facilitates a focus on understanding. Yager (1983) argues that, constructivism is a model of how learning takes place, rather than a theory of how rationality develops (p.301). The focus is the content of thought rather than the formal operations of logic that thought can involve. Piaget's theory of cognitive development and constructivism are compatible in that both deal with matching of tasks to a learner's cognitive capabilities. Piaget emphasises the cognitive readiness which determines the ability to learn. He also held constructivist perspectives such that all knowledge is constructed by the individual interacting with the environment (Osborne & Witrock, 1985:54). Information Processing is not far removed from a Piagetian model in that it also focuses on the individual's capabilities rather than the environmental factors in the process of cognitive development.

2.4 INFORMATION PROCESSING THEORY

Information processing approaches to cognitive development seek to describe learners' cognitive abilities and limitations at successive points in their development (Meadows, 1993: 212). This process of cognitive development is located within the learner who plays a vital role in the process of development and the key feature of the process is the growth of memory. Information processing research deals with the tracing of sequences of mental operations and their products as the individual performs a cognitive task (see Anderson, 1990). It also focuses on the processes by which individuals acquire and remember information and solve problems. The basic assumption of this theory, according to Siegler (1983), is that people are in essence limited capacity manipulators of symbols, and that analogies with the ways in which computers process information are helpful (p.129).

Computation is seen as the basis for human cognition and sometimes is used to test hypothetical accounts of the information-processing that goes into solving a problem. Human cognition is seen in this theory as active and constructive. Information processing occurs in successive stages. These stages include among others: sensory registers which receive external signals; short-term memory which is responsible for encoding of information and the long-term memory which is the storage system. For any information to be committed to memory, there must be a process of analysis and reformulation so that a deliberate interaction with the information is carried out.

Information processing theory is also concerned with the process of development. It assumes that knowing about adult information processing can lead to illuminating comparisons with learners' information processing. Learning and development of a skill or concept depends on complex cognitive structures. The extent of development of cognitive structures is seen to be what places limits on the performance of people. There are various models of cognitive development theories within the information processing paradigm (see Case, 1984; Kail and Bisanz, 1982 and Keil, 1979). Within this model successful learning is viewed as being more dependent on the learner's actions than on the events in the environment.

It is now important to consider the research done on proportional relationships in order to locate this within a wider framework. Proportional relationships are applied in diverse contexts and it is this wider application which warrants an understanding of them and of how learners approach problems which involve them together with strategies that they utilise in that process.

2.5 STUDIES ON PROPORTIONAL RELATIONSHIPS

Tourniaire and Pulos (1985) define a proportion as *"a statement of equality of two ratios"* (p.181). They further write that this skill is acquired late and is difficult to master by a learner since it involves a number of related skills which need to be mastered as well. Various methods of studying proportional relationships have been used over the last 25 years. The methods used to teach them have affected learners' reasoning abilities. Two types of contrasting methods have been used and these are: comparison problem versus missing values, and explanations versus answers only.

In a missing value problem, three or more numbers are presented and the task is to find the unknown x. In a comparison problem, the learner is presented with four numbers and the task is to find whether they can form a proportion using them. In an explanation question, the learner is asked to explain how the answer was reached, whereas, in the "answer only" type the answer needs to be stated or the correct answer chosen. It is clear that the answer-only type, particularly when used with a comparison problem, can lead to overestimating a learner's ability, since a correct answer can be generated from non-proportional reasoning (Tourniaire and Pulos, 1985, 183).

The methods used in doing studies on proportional reasoning have varied from individual interviews to paper and pencil tests. Within each method different kinds of tasks have been used and these include: physical tasks, rate problems, mixture problems and probability tasks. Inhelder and Piaget (1958) looked at physical tasks which required for success an understanding of some physical principles in addition to understanding proportions (p.183). These tasks have been criticised for requiring physical knowledge in addition to their proportion content (see Karplus et al., 1983). The most frequently used tasks in proportional reasoning studies are word problems, given with or without illustration and presented either in written or oral form. These are then sub-divided into rate problems and mixture problems.

In rate problems ratios of dissimilar objects are compared and the contexts vary. Mixture problems are also examples of word problems and the most widely known is Noelting's Orange Juice Puzzle (see Noelting, 1980), in which the tastes of two mixtures of orange juice and water have to be compared. Mixture problems are difficult for young learners in that the elements constitute a new object / substance. This requires understanding from the learner about the mixing of the two elements.

The instrument used in this study by the researcher could be answered by build-up strategies. This consists of establishing a relationship within a ratio and extending it to a second ratio by addition (see Hart, 1981). For example given the problem, "The candy store sells 2 pieces of candy for 8 cents. How much do 6 pieces of candy cost?", the child might say: "8 cents for 2, 8 more is 16 cents for 4 pieces, and 8 more is 24 cents for 6 pieces." This relationship between two ratios can vary in sophistication from primitive to rather sophisticated.

The strategies observed were those prevalent in childhood. They were found to be useful in achieving successful solutions to simple problems. They become cumbersome when the problem contains a non-integer (see Hart, 1981).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter provides a detailed analysis of the methods used in data collection. It also explains the original plan for this study, why the researcher failed to implement it, and the alternative plan which was then followed as a result of the problems experienced. It also gives information about the study site, sample used and who was involved in the study.

3.2 ORIGINAL PLAN

The aim of this study was to assess the effectiveness of a teaching approach based on the Means of Assisting Performance (MAP) in the teaching of science to grade five (standard three) level. The basic intention was to compare performances of three equivalent grade 5 classes at Khwezi Primary School using pre-test and post-test. Three grade five classes were used in this study. The first class (3A), designated as experimental group I, wrote pre- and post-tests and were taught for three weeks (4hours, 30 minutes) using an intervention which was based on the MAP teaching approach.

The second class (3B), designated as experimental group II, also wrote pre- and post-tests and received lessons which employed a "traditional" teaching technique. Experimental groups I and II were taught by the researcher. The third class (3C), designated as a control, wrote pre- and post-tests and was not to receive any instruction on the topics taught to 3A and 3B by the researcher. The third group was included in order to determine the test effect. Data from pre and post tests would be supplemented by qualitative observation of the learners at work, interviews with grade 5 teachers at the school and also interviews with some grade 5 learners. Existing classes were used in order to minimise disruption in the school.

Three of the 5 grade 5 classes were chosen by drawing class names out of a hat. The researcher had been told by the teachers in the school that all classes were of equivalent abilities and were also at a similar level. A general science topic (soil) was chosen from the grade 5 syllabus. The researcher planned that tests would focus on proportional reasoning skills, with the aim of keeping the study down to a reasonable size and enable an in-depth look at one skill rather than have superficial data covering several skills.

The researcher first observed the grade 5 science teacher for three weeks during the first quarter of the year. This was done in order to be sure of the style of teaching he was using during lesson presentation. In the second term (April-May) the researcher gave all three classes a pre-test which was later followed by the intervention programme. He taught class 3A for nine 30 minute lessons, using a MAP based teaching approach. Class 3B was also taught by the researcher for 9 lessons using a "traditional" approach. The traditional approach was based on the teaching style observed during the initial phase of this study. After the completion of the 9 lessons in both groups, a post-test was administered to all three classes.

3.3 PROBLEMS THAT AROSE

In this instance, this approach did not work as planned for the following reasons.

(i) The three classes were not of equal abilities. Class 3A contained more low scoring learners compared to the other two groups.

(ii) Without telling the researcher, the regular class teacher taught soil to standard grade 5C although he had agreed not to. This invalidated the use of grade 5C for measuring a test effect.

(iii) It also appeared that the pre-test and post-test items were not well matched and that some of the test items were not testing the skills the researcher had intended them to test.

(iv) It seemed unlikely that a short intervention of this nature could produce significant change in learners' performance on the general skill of proportional reasoning.

3.4 CHANGE OF EMPHASIS

It was therefore decided to change the emphasis of the study. Instead of concentrating on a pre-test/post-test comparison using a quasi-experimental approach, the study would concentrate on investigating the skill level of grade 5 pupils in proportional relationships in grade five at Khwezi Primary, and looking at strategies that learners at this level employ in solving proportional problems.

3.5 SOURCES OF INFORMATION

The revised study used the following sources of information. They are listed in chronological order and each source is explained in greater detail below.

(i) Observation of lessons presented by the grade 5 science teacher. This observation was done using the Classroom Observation of Science Teaching (COST) schedule. These lessons were also videotaped.

(ii) Initial trialling of pre-test items at Sinamuva Primary with grade 5 learners. Teachers were also asked to comment on the relevance of the questions.

(iii) Administration of the pre-test to three grade 5 classes.

(iv) The researcher taught the topic soil to grade 5A and 5B using different approaches as outlined above. Data were also collected during the intervention stage using the following methods.

  (a) Observations recorded after each lesson.

  (b) Interviews with some grade 5 learners on the approaches they used in solving problems.

(v) Administering a post-test to all grade 5 classes involved in the study.

(vi) Interviews with two grade 5 science teachers at Khwezi Primary on the teaching strategies that they find possible to implement and those they cannot implement in their classes, and the teachers' comments on learners' marks and on observations by the researcher.

(vii) In 1997 administration of a revised test using some items from the 1996 pre-test and post-test, to twenty 1997 grade 5 learners at Khwezi Primary.

(vii) Each of the twenty 1997 grade 5 learners was interviewed to find what strategies they used in solving the problems.

3.6 STUDY SITE AND POPULATION

The study of proportional relationships was carried out at Khwezi Primary School in Pietermaritzburg. The school is an ex-Department of Education and Training (DET), co-educational school and caters for grades 5 to 7. The racial composition of the school population is 100% 'African', of working class background. The medium of instruction at the school is English, although language-switching is the norm since learners are not well versed in English. Language-switching was also made possible by the fact that all teachers in the school are first language Zulu speakers. In 1996 the school had 468 learners, of whom 95 grade 5 learners took part in the study.

3.7 STUDY SAMPLE

The study was carried out using three classes of grade 5 learners. The three grade 5 classes were chosen randomly out of five grade 5 classes. This was done by drawing the names of classes out of a hat to assign them various roles in the study. The classes consisted of mixed ability groups and there was no streaming in the school, according to the principal's and teachers' information. Learners were randomly assigned to their classes at the beginning of the year. This was done alphabetically and not according to their academic abilities. This process was carried out at the beginning of the year, during registration. There were about 179 learners in grade 5. The sample comprised 95 learners. One teacher was directly involved in the study because he was responsible for teaching science.

3.8 DATA GATHERING

The data used in this study were collected using both quantitative and qualitative methods as a form of triangulation. The following methods for gathering data were used: systematic observation, video-recording, testing, interviews, general observation and worksheets.

3.8.1 SYSTEMATIC OBSERVATION

The subject teacher was observed during lesson presentation for three weeks. This was done to establish the nature of teaching approaches used by the teacher during lesson presentation. This information was useful in helping the researcher to develop a form of understanding regarding the "traditional" teaching method. Systematic observation was done using the Classroom Observation of Science Teaching (COST) schedule. Classroom Observation of Science Teaching is a schedule which contains a number of topics regarding processes that are supposed to happen during the science lesson. This schedule was developed and used successfully by McDonald (1987) in her study of classroom interaction at grade 5 level. The development of COST was based on the Science Teaching Observation Schedule (STOS) developed by Eggleston, Galton and Jones (1976). The use of COST was strategic since it was developed for the South African situation and specifically the type of school used in this study.

When a lesson is being observed on the basis of the schedule, the observer ticks specific activities which are covered within a specific period of time during the lesson. The researcher was able to establish the kinds of teaching approaches used during the lesson. These lesson observations became valuable in informing the "traditional" method used by the researcher during the lessons he gave to class 3B. Lesson presentation by the researcher was pivotal towards the success of the whole process since the use of the regular class teacher would have added another extraneous variable which might have meant training for the teacher concerned. Appendix IV contains all observations recorded.

Systematic classroom observation is a specific research technique which is not a complete and self-contained approach to educational research (see Croll, 1986). This approach was used in this study as a point of departure in the process of analysing classroom activities. Delamont (1976) used this type of approach where Flanders' instrument was used as a starting point in comparing the behaviour of learners but the main focus of that study was the qualitative observation of personalities of two teachers. The incorporation of both quantitative and qualitative methods ensured validity of the instruments used in this study.

3.8.2 VIDEOTAPING

All 9 lessons of the subject teacher which were observed were videotaped. This was done to complement systematic observation which is designed to focus specifically on a particular aspect of the lesson. The tapes were also used to further analyse lesson proceedings after systematic observation and to look at other events which might have been missed by the researcher during lesson observation.

3.8.3 TESTS

Tests were also used in this study to obtain quantitative data from learners. This exercise was done with all three classes which were involved in the study.

Data yielded information regarding the level of performance on the skill of proportional relationship, before and after the investigation. The tests also provided information on the strategies used by learners in solving proportional problems. A test was also given to 20 of the current grade 5 learners at Khwezi with the aim of finding strategies learners were using at this level. Learners were also required, during this test, to write down in their mother-tongue the reasons for choosing a particular answer. The researcher hoped that this would reveal strategies used by the learners in solving the problems.

3.8.4 INTERVIEWS

Interviews were carried out with both the teachers concerned and also the learners. This was done on an individual basis. After writing the tests 5 learners were randomly chosen from each class in 1996. 20 current (1997) grade 5 learners were also interviewed. The aim of interviewing teachers was to find out teachers' views of pupil expectations generated as a result of the kinds of teaching styles which were used in the classroom and also teachers' views of pupils' thinking patterns generated by the teaching styles used. The interviews carried out with the learners were based on the tests they had written with the aim of finding the kinds of strategies they used when solving these problems.

3.8.5 RESEARCHER'S OPEN OBSERVATION

Data were also obtained during the intervention process on the kinds of teaching and learning styles which were taking place in classroom. This was either recorded during the lesson, if opportunity arose, or immediately after the lesson. Most of the data on the lesson proceedings were recorded during the researcher's reflection stage which was always after each lesson. Informal discussions were held with other teachers regarding the progress of the pupils in other subjects. This means looking at other subjects where these skills are required in solving problems. This was in line with Oliver's (1992) thinking when he argued that

> *"....proportionality is a prerequisite for understanding and communicating in: daily life, e.g. comparing prices; physical sciences, e.g. pressure; geography, e.g. scales; agriculture, e.g. fertiliser ratios; woodwork, e.g. scale; mathematics; and needlework, e.g. scale" (p.297).*

Data obtained from the discussions with other teachers were used to confirm or refute the performance trends observed from the testing instruments.

3.9 DESIGN OF THE PRE-TEST

The pre-test was designed using Assessment of Performance Unit (APU) (1981) materials as a basis for the test. The APU materials were developed in the UK for testing processes of scientific thinking by learners at different ages. In choosing test items the researcher chose questions designed for the eleven year olds, that used the skill of discerning proportional relationships at its basic level of operation. Focusing on this skill was of importance since it narrowed down the field of study and also provided opportunities for detailed work to be done. The draft test papers were trialled with grade 5 learners at Sinamuva Primary in order to validate them. About 15 learners were also interviewed at Sinamuva Primary to determine the thinking patterns elicited by the test items and to determine whether the test items were testing what they were supposed to test. Teachers from the same school were also asked to comment on the materials so they could be modified to meet the local conditions.

3.10 PRE-TEST PROCEDURE

The pre-test was conducted during normal school hours. The researcher met the teacher and learners concerned two days before writing the test in order to explain to them the importance of the test. The learners were told that the test was not going to be part of their year mark but should be regarded as important. This was very important in trying to foster a stress-free environment without losing the seriousness of the whole task. The presence of the teacher was deemed crucial in trying to ensure seriousness on the part of the learners. The duration of the test was about one period (30 minutes). Each learner was given a copy of the test paper (see Appendix I).

The test consisted of a number of questions and each question was read out by the researcher two times to circumvent the reading problems of some learners. Because the questions were in English, the researcher had to ensure that each question was understood by all the learners and where necessary, the researcher translated questions into Zulu. This was carefully done without giving away the answers to the questions. It was also specifically stated to the learners that each answer would be an individual effort and the learners were given sufficient time to respond to the questions. All three classes wrote the test simultaneously in one room.

3.11 DESIGN OF THE POST-TEST

The post-test was also designed using the same procedure as the pre-test. The formulation of the questions was followed by trialling with learners from Sinamuva Primary through a paper-and-pencil test and eliciting comments from the teachers. The post-test consisted of questions which were structured in almost the same way as the pre-test. This procedure was followed since the pre-test questions were taken away from the learners immediately after they had completed the test.

3.11.1 POST-TEST PROCEDURE

The process of writing the post-test was fairly easy since a rapport had already been established with the learners. The post-test was administered in a similar way to the pre-test. The duration of the test was about 25 minutes owing to the fact that there were also explanations given and learners were given sufficient time to respond. Each question was read to the learners and there were also explanations where necessary especially in situations where the language got in the way. No teachers apart from the researcher were present during this testing and it was also done during normal school hours.

3.12 CRITICAL ANALYSIS OF THE METHOD

The testing instruments used in this study might have limited the amount of marks that the learners managed to acquire, due to the fact that they were not coupled with manipulatives. Manipulatives are concrete examples of the objects used in problem presentation. Several researchers involving Tourniaire (1986) and Kieren and Southwell (1979), have found that the use of manipulatives seems to strongly influence success on proportional problems. The meagre financial resources did not, however, allow the researcher in this study the privilege of using manipulatives.

The fact that the testing instruments were multiple choice might have led to some measure of overestimation regarding learners' capabilities of the skill under investigation. Instruments of this nature were put together because of the age level of the learners and their language development.

3.13 DESIGN OF THE INTERVENTION PROGRAMME

Three classes of grade 5 learners were involved in this study: experimental group I (class 3A) with 28 learners, experimental group II (class 3B) with 32 and the comparison group (class 3C) with 35 learners. The intervention in experimental group I took the form of nine lessons during a period of three weeks. Each lesson took about 30 minutes (these were single period lessons). The lessons followed the normal timetable of the school and they followed immediately on the pre-test. The post-test was done a day after the intervention. The design of lessons of experimental group I was based on the Means of Assisting Performance (MAP) by Tharp and Gallimore (1988). MAP aims to ensure full involvement of the learner during the lesson. This is regarded as one of the important factors in bringing about understanding.

Experimental group II received instruction which was based on "traditional" teaching which was going on at the school. "Traditional" teaching was characterized by lecture type teaching, the use of textbooks on many occasions, and teacher-talk was dominant in the classroom. The role of the learners was limited to observation, note taking, recitation and memorization. The control group in this study, as mentioned earlier, was supposed to have received instruction in all subjects except general science. But the teacher taught them about soils without the knowledge of the researcher. They also wrote pre-and post-tests. The intended control group therefore in reality constituted a third type of experimental group.

It should also be pointed out that the coming of a person from outside the school might have presented difficulties to learners since they had to get used to that individual as well. It is true that learners may have had difficulty at first but they should have got used to the new method as time went on. The use of the outside person was justified on the basis of removing extraneous variables, like inexperience in applying the required strategy, which might have compromised the results of the study.

CHAPTER FOUR : INTERVENTION PROGRAMME

4.1 INTRODUCTION

In this chapter two forms of lessons presented are shown: lessons based on the Means of Assisting Performance, and lessons based on "traditional teaching". The general characteristics of each type of lesson presented are first discussed followed by a discussion of the unique features of each lesson. Lastly, summaries of the two approaches to lesson presentation are then provided.

4.2 GENERAL FEATURES

4.2.1 EXPERIMENTAL GROUP I LESSONS (MAP)

4.2.1.1 INTRODUCTION

Each lesson was started in a whole-group fashion which was ideal for letting the class know about the activities of the day, going through homework with the whole class in order to save time, and also revising the previous day's work. Most of the instructions were given at this point of the lesson since they formed part of the process of assisting the learners. Questioning strategy was used in these lessons to assess pupils' understanding of the work done on the previous day, and assisting questions were designed specifically to help pupils to go through certain mental operations in order to demonstrate a level of comprehension.

4.2.1.2 PRESENTATIONS

The class was divided into about 4 heterogeneous groups of 7 or 8 pupils. These groups were then referred to as "activity settings" which are described by Tharp and Gallimore (1988) as "contexts in which collaborative interaction, intersubjectivity, and assisted performance occur" (p.72). The actual working in the class occurred in activity settings which were either Centre One activity or in general settings. Centre One referred to that particular group chosen by the teacher to focus attention on at a particular point in time. The teacher spent most of his time with Centre One groups where intensive interaction with the members of the group was taking place. Since the groups were heterogeneous-ability groups, they were assisted by the teacher to get to a particular point in their ZPD and then left on their own to do the rest of the work. Some of the Centre One groups were changed by the teacher to be homogeneous-ability as the need arose. This was aimed at giving the teacher the opportunity of helping learners through their ZPD. In this way learners of similar ability were assisted simultaneously.

Cognitive structuring as a means of assistance was mostly useful here to assist learners to develop the required mental operations needed to understand the work. Modelling was also used to show how to do things such as searching for answers in solving problems. Contingency management was crucial in this exercise since it provided the necessary reinforcement of the positive behaviour and with learners of this age level this was of major importance.

In the activity settings the groups were working independently and the teacher was monitoring them from a distance. These groups were heterogeneous ability groups and had a series of activities to carry out without the assistance of the teacher. The aim was to allow learners to move through their ZPD's with the assistance of their peers. Each group reported to the whole class about its findings, what progress was made and what problems were incurred. The teacher made a detailed report about the progress of each group and the areas in which they needed assistance.

4.2.1.3 CONCLUSION

Each lesson was concluded by means of the whole-group setting where the activities of the day were rounded off, homework given and summaries made. Instruction as a means of assistance was mostly used here in terms of what the learners were supposed to do. During this part of the lesson questioning was used but the questions used here were mostly assessing questions since they provided the teacher with valuable information to guide the next day's work.

4.2.2 EXPERIMENTAL GROUP II LESSONS ("TRADITIONAL") GENERAL FEATURES

4.2.2.1 INTRODUCTION

Each lesson was introduced in a large group setting. This part of the lessons was very brief since the main objective in doing this was to give instructions to the learners. Questioning was mainly used especially when summarising the previous day's lesson. Classroom organization did not feature strongly since the approach used was familiar to the pupils.

4.2.2.2 PRESENTATION

The lessons presented were mostly characterized by teacher-talk, with learners exercising their listening skills. There was little group work and the teacher followed a 'recitation script' in which memorising was the order of the day. Sometimes learners were asked to sit in groups but there was no actual group performance on the task, instead learners were encouraged to work independently. There was a division between teaching and learning, in which learners were doing their own work and whether they understood or not did not matter. There was no deliberate attempt by the teacher to assist learners with the task at hand. There was, however, a sense of urgency to complete a certain amount of work, at whatever the cost to learner understanding.

Practicals consisted of demonstrations on the part of the teacher and learners' activity was simply observation. When a practical was done, the sole purpose was for the learners to observe what was done by the teacher. Learners were expected to be recipients of information. The questions that the learners were required to work with were low level questions which mostly dealt with recall, knowledge and fact. There was no deliberate attempt to inquire about learners' knowledge and experiences.

4.2.2.3 CONCLUSION

The questions that were asked during the conclusion stage of the lesson were mostly of an 'assessing' type and designed to measure performance. They were not designed to help learners go through certain mental operations with the aim of assisting learners through their ZPD's.

4.3 LESSONS PRESENTED

The following is a lesson by lesson summary of the group I (MAP based) and group II ("traditional") lessons showing how the general frameworks described above were translated into the classrooms.

4.3.1 LESSON ONE

GROUP I LESSONS

SOIL FORMATION

INTRODUCTION

Learners were divided into groups. They were then told how they were expected to work in the groups. The teacher did his best to ensure that learners were clear about the expected behaviour in class. Using the large group format, the lesson of the day was introduced.

PRESENTATION

Learners were asked to work in groups in answering questions on the uses of the soil. Charts were brought in for the learners to analyse. Each group was then asked to make a presentation at the end of the discussion. Groups were given stones so as to demonstrate soil formation. Magnifying glasses were used to observe the nature of the material. Assisting each other in the group was a very important aspect of this exercise. Groups were also assisted by the teacher. Practical experiences were also used in helping learners to understand better.

CONCLUSION

Groups were asked to make reports on what they found. This helped the teacher in monitoring the progress of the groups. A summary of the lesson was made using questions to prompt answers from learners. Homework was then given where learners were required to collect a sample of soil and spread it over a newspaper in order to observe its contents. The following questions were used as guidelines during observation.

1. Name the things that you found in the sample of soil.
2. Describe the material found.

LESSON ONE

GROUP II LESSONS

SOIL FORMATION

INTRODUCTION

The main topic of the lesson was introduced to the learners in a large group format. The lesson of the day was also introduced in a similar way.

PRESENTATION

The teacher started by telling the learners about the importance of the soil. He also told the class about how soil is formed. He then wrote notes on the board on soil formation for the learners to copy. A demonstration was then carried out by the teacher on soil formation. Learners were asked to answer questions in the book on soil formation.

CONCLUSION

The teacher concluded by making a summary of the main points.

- soil is important for plant growth.
- soil is important for building.
- it is a home for animals.
- soil is formed when stones collide.

Learners were then given questions to do at home.

1. Name the things found in the soil.
2. What is the colour of the soil?
3. Are there plants in the soil?
4. Are there animals in the soil?

4.3.2 LESSON TWO

SOIL CONTENT

INTRODUCTION

The lesson was started by asking group members to share with others information on what they had found on the soil samples studied. The class was briefed on the activity of the day, which was comparing the two samples of the soil studied.

PRESENTATION

Learners were asked to compare the two samples studied using the following.

- what is colour of each sample?
- are the two samples similar?
- which one is similar to the soil observed at home, and how?

The groups identified as having problems were assisted by the teacher. The process was very important in that the teacher wanted to develop a cognitive structure that the soil was more than just rock.

PROPORTIONS

Proportions at the most basic level were introduced e.g. the more plant material in the soil, the higher is the soil fertility. Learners were also required to give examples from their life experiences as a form of anchoring. Figures were gradually introduced, e.g. if x amount of humus is added, the plant would grow y size. A lot of modelling was done by the teacher on strategies of solving these type of problems.

CONCLUSION

The lesson was concluded by a whole group session where various aspects of the lesson were discussed. Learners were given problems to solve as groups and they were encouraged to assist each other in solving the problems.

LESSON TWO

SOIL CONTENT

INTRODUCTION

The lesson was started by making a summary of the previous day's work. Learners were also given answers to the questions given the previous day.

PRESENTATION

The teacher started by telling the learners that the soil is important.
These were salts, water, plants, animals etc. A class demonstration on soi composition was done by the teacher. I involved adding water into the soil shaking it and putting the container on the table for a while. Various layers of the soil were observed as the soil particles were settling down.

PROPORTIONS

The idea of proportions was introduce where the soil fertility was related to plan material available in the soil.

CONCLUSION

A summary of the main points was mad by the teacher where the soil component were mentioned. Learners were asked t bring the different types of soil to th class the following day.

4.3.3 LESSON THREE

SOIL COMPONENTS

INTRODUCTION

Learners were asked to share experiences on the homework and to create and foster the attitude of homework as a joint activity. They were also asked to demonstrate to the others the strategies they had used in solving problems. This was important in developing the social aspect of learning.

PRESENTATION

Learners were asked to mix soil and water and then discuss in groups what was happening and record their observations. A group was identified by the teacher for a detailed discussion of what was observed. This was done to help the learners through the motions of what was expected of them and the type of questions that they could ask. Once the group was taken through the ZPD, other groups were identified for help. Learners were able to observe the separation of the particles according to their masses.

PROPORTIONS

Learners were assisted in seeing proportional relations by using the mass of the particle and its relative position in the cylinder. Groups were then asked to report on the progress made.

LESSON THREE

SOIL TYPES

INTRODUCTION

Learners were asked to show the samples they were requested to bring to class. Previous day's work was summarised by the teacher and the lesson of the day was introduced. He told the class that there were three types of soil and these have different characteristics.

PRESENTATION

The three types of soil were shown to the learners for observation. Learners were informed about these differences which have to do with:

- spaces between soil particles
- water retention
- size of the particles
- amount of plant material.

PROPORTIONS

Proportions were incorporated by lookin at spaces between particles and the so types.

CONCLUSION

Learners were asked to write journals on the things that they had learned in that lesson. They were then given a worksheet to complete at home.

WORKSHEET

SANDY SOIL

(i) Did the water separate the soil into layers?

....

(ii) Was the water clear?

....

(iii) What were the particles like at the bottom of the cylinder?

....

CLAYEY SOIL

(i) Was the soil separated into layers?

....

(ii) Was the water clear?

....

(ii Describe the particles at the bottom of the flask.

LOAMY SOIL

(i) Were the different layers observed?

....

(ii) Was the water clear?

....

(iii) Which layer had the largest grains of sand?

....

(iv) Explain what you observed at the top of the cylinder.

....

(Redelinghuis et al.,1980:24)

CONCLUSION

A summary of the salient points of the lesson was made. Extensive use of questions as a form of revision was carried out.

4.3.4 LESSON FOUR

SOIL TYPES

INTRODUCTION

The lesson was started by looking at the worksheet given. Learners were to give assistance to those who were battling with the task. The lesson on soil types was then introduced.

PRESENTATION

Groups were presented with types of soil and were asked to come up with criteria that they could use in classifying the types of soil. The teacher identified a group to be assisted. The teacher tried to use questions to develop the structure of the learners' thinking about the existence of soil types relative to the different types of plants and their needs. Different groups were able to come with the bases for classification which were: colour, texture, smell, grain size etc.

PROPORTIONS

The idea of proportions was incorporated using grain size proportional to the amount of air, percolation rate and inversely proportional to water retention.

CONCLUSION

Problems on proportions were given to the groups to solve.

LESSON FOUR

WATER RETENTION

INTRODUCTION

The lesson was introduced by asking learners about the capabilities of the soil, including water. Links with the previous lesson were made by revising the work done previously.

PRESENTATION

During the presentation learners were told about water retention, and its role in plant survival. Water is one of the main components necessary for plant growth. A demonstration was carried out by the teacher to show water retention. A sample of soil was added into a funnel placed on the flask and irrigated with water. The amount of water coming out was compared to the amount added.

PROPORTIONS

Proportions were incorporated looking a the amount of water added compared t the water coming out. All three types o soil were looked at.

CONCLUSION

Learners were given questions to answe and these were:

- which beaker has the most water?
- which beaker had the least water?
- which beaker had the most water?
- which kind of soil retained the most water?

4.3.5 LESSON FIVE
WATER CONTENT OF THE SOIL (a)

INTRODUCTION
The lesson was started by a large group discussion on the work done the previous day. The teacher tried to focus learners' thinking by asking them to share with the class their experiences on whether the soil is capable of retaining water, and if that is the case, what would be the role of that water.

PRESENTATION
Learners were asked to investigate water retention of the soil. Three samples of soil were placed in the funnel and water was added to measure the retention capacity of the soil. Learners were asked to compare the amount of water added and the amount of water that came out. All three soil samples were measured. Learners were then taken through a series of questions based on the activity.
- which beaker has the least water?
- compare the amount of water in the containers and explain what is there.
- which soil retains the most water?
- which soil retains the least water?
- which soil allows water to pass through quickly?

PROPORTIONS
- Water retained is inversely proportional to the particle size.
- Water passing through is proportional to the particle size.

CONCLUSION
A summary of the lesson was made using the questioning strategy. Problems of various groups were monitored and a homework was given on proportions.

If 10g of soil holds 4ml
20g of soil holds ?ml
?g of soil holds 12ml
40g of soil holds ?ml

LESSON FIVE
INVESTIGATING THE PRESENCE O
WATER IN THE SOIL

INTRODUCTION
A summary of the previous lesson wa done. Answers to the previous day' questions were given to the learners an the lesson of the day was introduced.

PRESENTATION
The teacher told the learners about th importance of water in the soil. He als made it clear that without water plant would not survive. He then proceeded t demonstrate the presence of water in th soil by heating a sample of soil in a ja sealed with cotton wool. Water vapo started to accumulate inside the bottle.

PROPORTIONS
Proportions were looked at regarding th amount of water released compared to th amount of water added.
- Amount of water released proportional to the size of the particle

CONCLUSION
The teacher summarised the lesson I going through the important parts of tl lesson with the learners. Homework proportions was the same as in grade 5

.3.6 LESSON SIX

VATER CONTENT OF SOIL (b)

NTRODUCTION

The problems of the previous day were liscussed and those who needed assistance were helped. The lesson of he day was then introduced.

PRESENTATION

The aim of the lesson was to investigate whether the soil is capable of holding water. This was to be done by half filling a jar with soil and closing the jar with cotton wool. After heating the soil for a while small droplets were seen inside the bottle. The aim of this investigation was to show learners that the soil is capable of retaining water which is important for plant growth. A link was established with the previous lesson regarding the amount of water retained by a particular type of soil.

CONCLUSION

Group discussion was held on the salient points of the lesson. The teacher tried to make learners see the value of the investigation which was undertaken.

LESSON SIX

AIR CONTENT OF THE SOIL

INTRODUCTION

A summary of the previous lesson was done with the class before introducing the day's lesson. The teacher then introduced the lesson on soil components.

PRESENTATION

The teacher informed the class about things found in the soil e.g. water, salts, plants, animals, air etc. They were then told that air is very important for the plants to breathe. The presence of air in the soil was then demonstrated. A jar was half filled with soil and then water was added. A lid was placed on the jar followed by mixing the two. A space was then observed under the lid. Learners were then told that the nature of the soil determines the space that is found. The were ask to predict an amount of space based on the amount of soil.

CONCLUSION

A summary of the main points was made which included that soil contains air and it plays a role in the survival of the living organisms.

4.3.7 LESSON SEVEN
INVESTIGATING AIR CONTENT OF THE SOIL

INTRODUCTION
The lesson was started in a large group setting by going through the main points of the previous lesson. The soil contains more than just plants which fertilize it, there is also water which is also important for plant growth. Groups were then asked to look at the previous day's work and those who experienced problems were assisted.

PRESENTATION
Learners were asked to do an investigation on the presence of air spaces in the soil. Learners were asked to mix soil and water to the brim of the jar. Groups were asked to observe very carefully what was happening and discuss as a group what they have observed. By using a series of process questions , the teacher encouraged the learners to think about what they had seen. Contingency management was utilized to re-inforce positive behaviour. Learners were asked to repeat the same procedure but with different soil samples in order to compare them.

PROPORTIONS
Proportions were introduced on the amount of soil compared with the amount of space observed.

CONCLUSION
Questions were used to recapture the salient points of the lesson. Soil contains air which plays a very important role in plant growth and other living organisms found in the soil.

LESSON SEVEN
SOLUTES IN THE SOIL

INTRODUCTION
Revision of the previous day's work was done by means of questions. This was done in a large group format. The lesson of the day on solutes was then introduced.

PRESENTATION
A long exposition was given to the learners about solutes, their role in the soil, their origin and their importance in plant growth. Notes were then written on the board on what the teacher had been saying. Learners were also required to recite what was on the board. The teacher then boiled water with solutes and after evaporation of water a whitish substance remained.

PROPORTIONS
This involved looking at the amount of solutes in the soil relative to soil fertility.

CONCLUSION
A summary of the lesson was done by looking at the salient points: solutes are present in the soil and they are plant food and their sources vary.

4.3.8 LESSON EIGHT
INVESTIGATING THE SOLUTE CONTENT OF THE SOIL

INTRODUCTION
Learners were asked to discuss the previous lesson in groups. Importance of the air and other organisms in plant growth were mentioned. The lesson of the day on solutes was then introduced.

PRESENTATION
Learners were asked to read through instructions on how to investigate the presence of solutes in the soil. Soil was mixed with distilled water and the mixture was filtered. The filtrate was then boiled until it completely evaporated. A whitish substance remained and this contained mineral salts. The salts are food for the plants. Plants that lack these salts develop a variety of symptoms. Mineral salts can be mixed with fertilizers which come in different forms. Learners were also asked to name things which are 'thrown' into the garden with the aim of increasing soil fertility. These could be plants, animals, artificial fertilizers etc.

CONCLUSION
The summary of the lesson was made by asking learners to talk about things they learnt about in the lesson. They were able to point out the important connection between the needs of the soil and plant growth so as to produce food.

LESSON EIGHT
FERTILIZERS

INTRODUCTION
A summary of the previous day was made. Learners started to share among groups various ways of fertilizing the soil. The lesson of the day on the types of fertilizers was then introduced.

PRESENTATION
Learners in this lesson were told about fertilizers and their importance in the soil. They were also told about man-made fertilizers and natural fertilizers. Natural fertilizers include animal manure, plant manure, compost etc. Each type of fertilizer has a specific role to play.

PROPORTIONS
Proportions were included on the amount of fertilizer added and the related plant growth.

- 10g fertilizer - 5cm taller
- 15g fertilizer - ?cm taller
- ?g fertilizer - 15cm taller

CONCLUSION
The lesson was concluded by mentioning the important points. Plants need nourishment in order to continue producing food.

4.3.9 LESSON NINE
IMPORTANCE OF THE SOIL

INTRODUCTION

The aim of this lesson was to try and put together the important points about the soil. Learners were asked to work in groups and assist each other in developing this summary on the importance of the soil.

PRESENTATION

The teacher tried everything to ensure that all learners were able to progress through their ZPD's in relation to the importance of the soil. Intensive questioning was used to help learners recollect the important points raised in the series of lessons. Assistance in this regard emanated not only from the teacher but from all sides. Metacognition was used in trying to help learners recollect past experiences. Groups were later called to report on the progress made to ensure that learners were on par on the knowledge received.

CONCLUSION

It became apparent at the end that the soil is important in providing food, but for it to continue to do so, it needs to be cared for as well.

LESSON NINE
IMPORTANCE OF THE SOIL

INTRODUCTION

The lesson of the previous day was revised with the learners. Learners were to write down things that they could remember about the importance of the soil.

PRESENTATION

Learners were asked to remember things that were mentioned as important about the soil. The task was individualistic in its approach. The teacher assisted those who needed help by putting answers on the board. The teacher then made a summary of the whole work done on soil.

CONCLUSION

The soil is the lifeblood of the living organisms and for it to do so, it needs care and attention.

4.4 SUMMARY OF EXPERIMENTAL GROUP I LESSONS

The group I lessons covered the processes involved in the formation of the soil such as stone crushing; soil components such as gravel, clay and humus; types of soil, such as clay, loam and sand; water content of the soil; air content of the soil; salt content of the soil and the importance of soil in nature. These lessons were aimed at fostering joint activity between learners and the teacher. They were also aimed at providing learners with the opportunity to do things for themselves, to use their background knowledge and to play an active role in the learning process.

Amongst the skills that the researcher planned to develop in the lessons were proportional reasoning calculations. Time was also spent on the style of reasoning in dealing with proportional problems. Great emphasis was also placed on group discussion skills. MAP is based on co-operative learning. As a result, learners were expected to develop skills on how to put this style of learning into practice. The language factor was critical in this style of learning because of the age level of the learners. The researcher had to ensure that the language used was not beyond the developmental level of the learners, therefore, materials were simplified to achieve this. Continuous intervention using the mother-tongue also played a very important role in ensuring that the learners were always clear on what was supposed to be done.

4.5 SUMMARY OF EXPERIMENTAL GROUP II LESSONS

The lessons of experimental group II covered the same ground as experimental group I which involved soil formation; soil contents; soil types; air in the soil; water in the soil and the importance of the soil. What differentiated these lessons from those of experimental group I was the nature of delivery and the roles of learners in the learning process. Delivery was teacher-centred, with very little or no learner involvement, no group activities and a lack of utilisation of learners' prior knowledge. Learner activities included recitation, note-taking, and observation. There was very little homework done by learners in this group.

CHAPTER FIVE : ANALYSIS AND DISCUSSION OF DATA

5.1 INTRODUCTION

In this chapter the following results are reported in order to derive some meaning from the data obtained during the course of the investigation.

- Mean scores for all classes in pre- and post-tests
- Histograms showing distribution of individual scores
- Histograms showing pupils' gains between pre- and post-test
- Scores for each question, class by class
- Correlation between pre and post-test scores
- Relationship between gender and performance
- Hypothesis explaining lack of correlation between pre- and post-test
- Kinds of answers given, and listing of codes obtained per question
- Explanation of results in particular questions
- Comparison with other studies
- Effects of different teaching styles between the two experimental groups
- Qualitative data presentation

5.2 QUANTITATIVE DATA ANALYSIS (PRE AND POST-TEST RESULTS)

The method used in trying to make sense of the quantitative data was first to mark each question as either correct or wrong. Each answer given was also coded: a for blank, b for correct, c, d and e etc as distracters. A table showing codes for each question is included in the text. Data obtained in this way was then entered into a computer spreadsheet programme for sorting to find patterns. The file was then transferred into a statistical programme for plotting scatter diagrams and histograms.

The results of the pre-test and post-test scores seem to suggest that, generally learners tested were not doing well on proportional skills. This is clearly shown by the mean scores for all three classes in pre-test and post-test shown in Table I.

TABLE I : *Mean total scores for pre-test and post-test* (n=95)

Max. possible scores: PRE-TEST = 05 POST-TEST = 5

Class	Pre-test	Post-test	Total (out of 10)
5A	1.9	1.7	3.6
5B	2.1	2.2	4.3
5C	1.9	1.9	3.8

This undoubtedly shows low scoring pattern emerging in all three classes. The questions used in this analysis were those which were testing proportionality. What is also apparent from this table is the similarity of the scores for the two tests in all three classes. Figure I shows a histogram for individual pre-test scores for all three classes. It is clear from both that the majority of learners were scoring 2 or less out of 5. Figure II is also a histogram for individual post-test scores for all three classes. What these results are reflecting is a low scoring pattern emerging from the tests.

FIGURE I AND II : Individual pre and post-tests scores for all three classes(n=95)

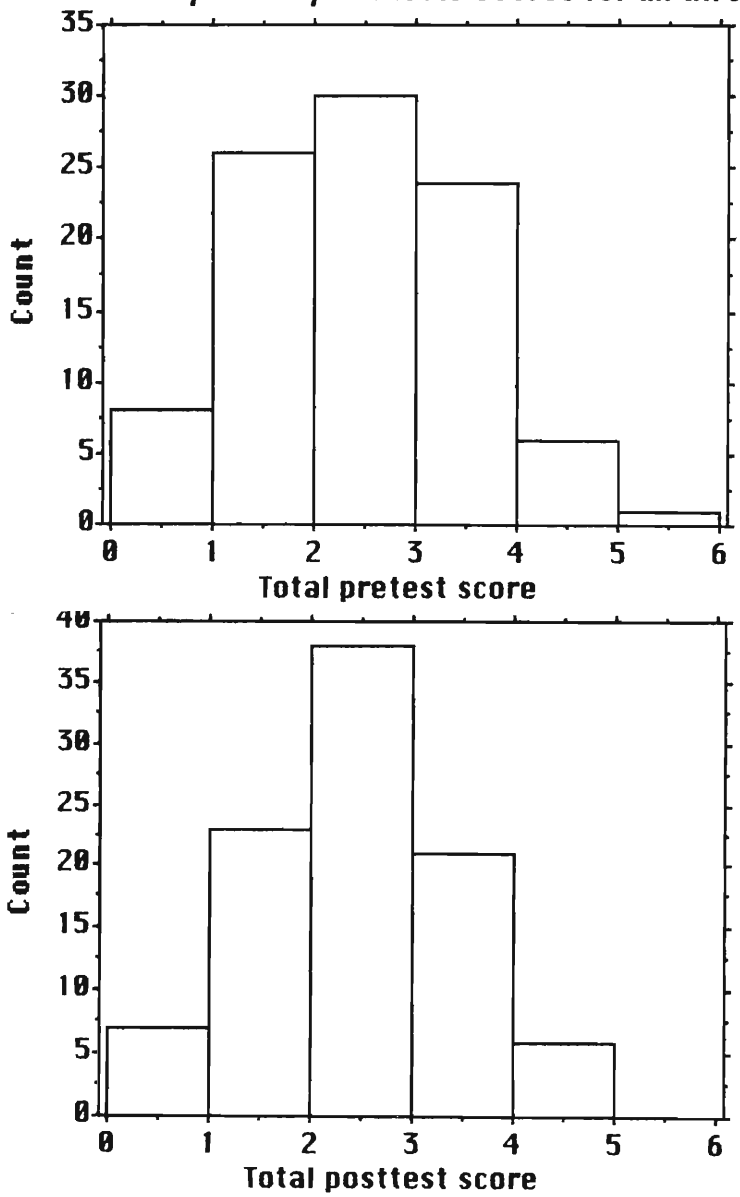
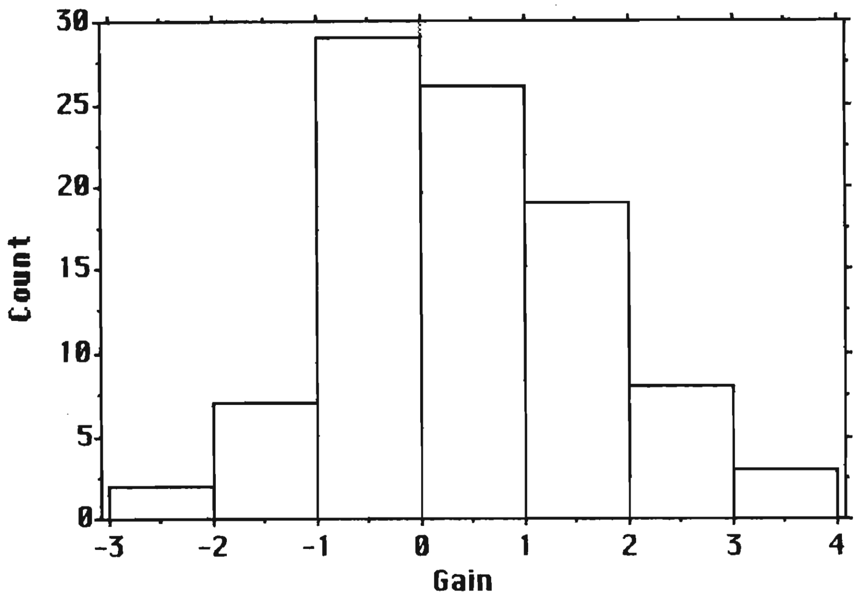


Figure III shows net individual gains in scores for all three classes between pre-test and post-test results and the results seem to suggest that generally there was no gain in performance. About 40% of the learners scored lower on the post-test than on the pre-test. The lack of correlation between pre and post-tests scores is discussed further on page 86 *et seq.*

FIGURE III
Net individual gains between pre-test and post-test for all three classes (n=95)



This general analysis of data is not revealing much, partly because both sample sizes and possible scores were low. Therefore a detailed analysis of performance per question was undertaken to provide more information on how the learners were doing. Table II shows a breakdown of scores for all questions, and it is clear that Grade 5A had a slight improvement in three different questions (questions 1,3 and 5)compared to the other two groups. This is despite the fact that Grade 5A was trailing in overall performance.

TABLE II
Mean scores for all pre- and post-test questions (n=95)

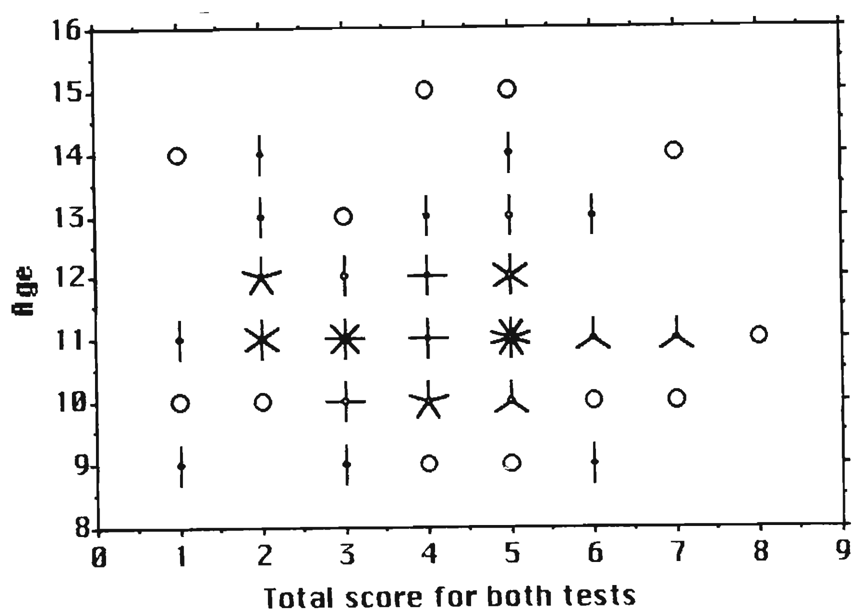
	PRE-TEST						POST-TEST				
	QI egg	Q2 leav	Q3 cog	Q4 dist	Q5 tree		Q1 egg	Q2 leav	Q3 cog	Q4 dist	Q5 tree
5A	0.39	0.64	0.14	0.46	0.25		0.46	0.61	0.21	0.11	0.32
5B	0.47	0.59	0.31	0.31	0.41		0.53	0.63	0.31	0.19	0.56
5C	0.43	0.54	0.37	0.23	0.34		0.4	0.51	0.26	0.29	0.46

From this analysis, it was also observed that learners were doing relatively well in questions which involved no numerical data. The case in point here is question 2 of the pre-test and question 2 of the post-test. Learners were also found to be doing badly in questions that involved numerical data, which were, questions 3 and 4.

This observation suggests that learners at this level are not ready to tackle problems with numerical data since the fundamentals of proportionality are still to be developed. It is also possible that most of these pupils do not connect numbers with the objects with presented.

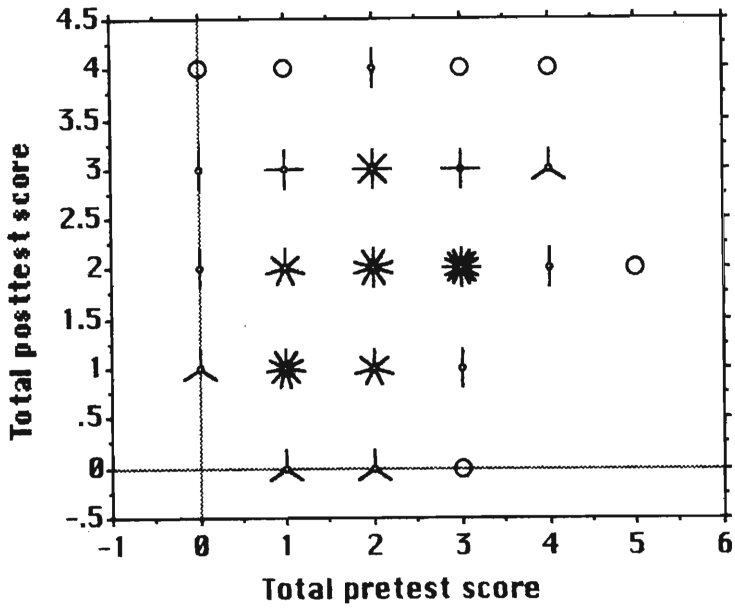
The results also seemed to suggest a lack of correlation between age and total score in the group tested. The correlation coefficient between age and the score was 0.01. Figure IV shows a scattergram depicting the correlation between age and total scores obtained.

FIGURE IV: Correlation between age and score obtained for all pupils (n=95)



There was also a lack of correlation between the pre and post-test scores. Figure V is a scattergram showing the relationship between pre and post-test score. The scattergram seems to depict no clear relationship. A very low correlation coefficient is also seen between the scores on the two tests which also confirms a lack of relationship between the two test scores. Those who did well in the pre-test did not necessary do well in the post-test.

FIGURE IV
Correlation between pre and post-test performance for individual pupils in all three classes (n=95)



One obvious possible explanation would be that pupils are choosing answers to the multiple choice questions more or less at random, and this is why there is little correlation between pre-test and post-test scores. A closer examination was made of the pattern of responses to each question, to see to what extent this "random guessing" hypothesis would hold, or whether strategies other than guessing were clearly involved.

In testing the "random guessing" hypothesis, the responses chosen in each question were analysed with the aim of finding the extent to which this crude hypothesis could be sustained. The "random guessing" hypothesis was stated as follows:

(a) some pupils understood how to get the right answer and they did, while

(b) all other learners guessed randomly among the 4 multiple choice alternatives.

Following this argument, there should be a roughly equal distribution of responses among the wrong alternatives. By calculating the average number of codes for wrong answers and then subtracting that number from the number of correct responses, one would then be able to estimate how many of those who got the answer correct had just guessed it. A worked example will illustrate this reasoning.

For example, the codes for question 1 on the pre-test are as follows.

Response	*no. of pupils*	
a	0	(blank)
b	41	(correct)
c	21	
d	15	
e	18	

Appendix III shows what letter was used to code each multiple-choice response.

The average for the incorrect responses c, d, and e is 18. We would therefore predict 18 guesses for b. If 18 is subtracted from 41 which is the number of correct responses, one would predict the number of those who actually worked out the right answer to be 23. One would also predict that, assuming learners' understanding had not improved between pre- and post-test, 23 would get the similar question right in the post-test without guessing. Appendix III shows a breakdown for all questions in an attempt to calculate the level of guessing in answering questions. It then became clear that a simple random guessing hypothesis could not be sustained for questions 2 and 4 in particular due to an uneven spread of responses.

5.3 STRATEGIES LEARNERS USE IN SOLVING PROBLEMS

It became clear that, alleging that all learners were guessing would be glossing over very important data. Strategies which were used by learners in solving proportional problems were analysed. This process would have been difficult without the interviews and the explanations given by the learners in the mother-tongue, since the format of the questions was a multiple-choice type. The explanations were categorised using a strategy scale taken from by Karplus et al. (1983). Strategies used by learners on proportional problems as categorised by Karplus et al. (1983) are shown below.

STRATEGIES ON PROPORTION PROBLEMS

Example:** **There are two mixtures of orange juice and water. One is made with 2 glasses of orange juice and 4 glasses of water. The other is made with 6 glasses of orange. How much water should be used to get the same taste?

Incomplete Strategy

--6, because there are 6 glasses of orange juice.

Qualitative Strategy

--10, because there is much more orange juice, so there should be much more water.

Additive Strategy

--8, because there should be 2 more water than orange juice.

Proportional Strategy

--12, because there should be twice as much water as orange juice.

--12, because we used 3 times as much more orange juice, so we need 3 times as much water

There were no additive strategies in the problems used in this study. This is not surprising, additive strategies have been shown not to be present in all contexts (Karplus et al. 1983:404). Tourniaire (1986) argues that, "*the structure of a problem determines the answer and explanations given*" (p.405). He therefore argues that proportional reasoning is, at first, an essentially fragmented ability. The techniques used to solve different problems are not related.

Some strategies are worth discussing in detail since they were pertinent in this study. An incomplete strategy was observed in a number of questions. In using an incomplete strategy, learners were ignoring part of data in solving the problem. In question 1 for example, learners were missing that the size of an egg determined the number of days it took to hatch; question 2 that the size of the leaf determined the amount of water lost; in question 3 the fact that the cogwheel was half the chain wheel; and in question 5, that the height determined the number of rings. Hart (1981) and Karplus et al. (1983) call this a developmentally primitive strategy which is used with some frequency by adolescents (cited in Tourniaire and Pulos (1985:185).

Tourniaire and Pulos (1985:185) argue that incomplete strategies may be caused by either misusing a correct strategy or can be a consequence of using an inappropriate strategy. They further argue that when using an incomplete strategy including unit values, an assumption is made that the unit value is the number of objects the problem starts with. For example, if the problem is: "*2 notebooks cost 8 F. How much do x notebooks cost?*" the child assumes that each notebook cost 2 F. This was observed in this study especially in question 3 and question 4 which said: "If you turn the chain wheel round once how many times will the cogwheel turn?" the child assumes the answer to be once, and " How long would it take to reach the town 120 km from Pietermaritzburg?" the child also assumes the answer to be 120 minutes.

5.3.1 STRATEGIES USED IN EACH QUESTION

The strategies used by the learners differed with each question. This is clearly seen where some strategies are observed in particular questions and not in others. In this section, each test question is discussed under the following headings.

A. Codes and strategies. This includes the frequencies of each kind of response.

B. Strategies in use from interviews. This outlines the strategies described by pupils during interviews (after the tests).

C. Possible reasons for strategies in use.

D. Teaching approaches suggested in order to remedy the situation.

QUESTION I PRE-TEST "EGGS"

A CODES AND STRATEGIES

code	no.	answer	strategy
a	8	Blank	
b	44	A. 14 days	Proportional strategy
c	17	B. 30 days	Incomplete strategy
d	15	C. 19 days	Incomplete strategy
e	11	D. 21 days	Clear guess

n=95

QUESTION 1. POST-TEST "EGGS"

CODES AND STRATEGIES

code	no.	answer	strategy
a	0	Blank	
b	41	A. 33g	Proportional strategy
c	21	B. 38g	Incomplete strategy
d	15	C. 43g	Incomplete strategy
e	18	D. 39g	Incomplete strategy

n=95

B STRATEGIES IN USE FROM INTERVIEWS

The interview session displayed three different strategies used by learners in answering this question. The first group consisted of learners who were using a proportional strategy. When they were interviewed they clearly explained the relationship between the size of the egg and the number of hatching days. The second group consisted of the learners who used an incomplete strategy. They only looked at a section of data and ignored the rest, the part looked at was the number of days but the egg size was totally ignored. The third group consisted of a "clear guess" group, they chose a figure which is not related to any thing. About 50% of the learners interviewed were able to give correct responses in this question.

C POSSIBLE REASONS FOR STRATEGIES IN USE

A number of postulations could be made regarding the use of these strategies. From the interviews, where they were held before teaching, and subsequent teaching in the two classes, it became apparent that learners were not used to critical observation. They could not look at a whole, break it down into components and assemble again at a very basic level. This suggested that practical activity was not done in class to introduce learners to the skill of observation. Selective observation (ignoring important aspects) which is practised mostly by unskilled observers was prevalent in this case.

D TEACHING APPROACHES TO REMEDY THE SITUATION

This problem could be addressed by exposing learners to practical activities where observation of several attributes would play a major part. Learners could be asked to interpret illustrations where they would be required to analyse and synthesise. Any activity that could show relationship between parts which constitute a complete whole would also be helpful.

QUESTION 2 PRE-TEST "LEAVES"

A CODES AND STRATEGIES

codes	no.	answer	strategy
a	0	Blank	
b	58	A (smallest if,)	Proportional strategy
c	6	B	Qualitative strategy
d	2	C	Qualitative strategy
e	29	D (largest if,)	Incomplete strategy

n=95

QUESTION 2 POST-TEST LEAVES

CODES AND STRATEGY USED

code	no.	answer	strategy
a	0	Blank	
b	55	D	Proportional strategy
c	36	A	Incomplete strategy
d	3	B	Qualitative strategy
e	1	C	Qualitative strategy

n=95

B STRATEGY IN USE FROM INTERVIEWS

Three strategies were used by learners in trying to solve the problem. The first strategy was the proportional strategy which required them to link the size of the leaf and the amount of water lost. The second strategy was the qualitative strategy where learners assumed that any leaf less than the bigger one would be correct. The third strategy possibly used verbal cues, since the question includes the words "biggest" and "smallest" (pre-test) and "smallest" and "highest" (post-test). In looking at the distribution of responses, they were not evenly spread. It therefore became clear that pupils were not guessing randomly but something was making them to choose A and D. When pupils were asked to say why they were choosing D, they were unable to explain.

C POSSIBLE REASONS FOR THE STRATEGIES USED

A high level of performance was observed in this question. This question did not involve any figures and learners seemed to do well in this type of question. However, the second most popular answer is the most incorrect. Pupils were choosing between two answers and it was difficult to say why.

D TEACHING APPROACHES TO REMEDY THE SITUATION

Teaching learners proper use of strategies at a very young age is of utmost importance. The introduction of proportions and word problems without using figures would be ideal. This could then be followed by problems involving integers and later on non-integer problems. Peer learning and giving learners the opportunity of negotiation would play a critical role in overcoming this problem.

QUESTION 3 PRE-TEST BICYCLE

A CODES AND STRATEGIES IN USE

codes	no.	answer	strategy
a	0	Blank	
b	27	C. 2 turns	Proportional strategy
c	13	A. half turn	Incomplete strategy
d	19	B. once	Incomplete strategy
e	21	D. 5 turns	Qualitative strategy
f	15	E. 10 turns	Qualitative strategy

n=95

QUESTION 3 POST-TEST BICYCLE

CODES AND STRATEGIES IN USE

codes	no.	answer	strategy
a	1	Blank	
b	25	C. 2 turns	Proportional strategy
c	13	A. half turn	Incomplete strategy
d	24	B. once	Incomplete strategy
e	21	D. 5 turns	Qualitative strategy
f	11	E. 10 turns	Qualitative strategy

n=95

B STRATEGIES IN USE FROM INTERVIEWS

Some learners were able see a ratio of 1:2 in the data. They were able to say that whatever happens in the chain wheel will occur twice in the cogwheel. This group demonstrated a proportional strategy. The second group was an incomplete strategy group which argued that since the cogwheel is half the chain wheel, the cogwheel would make a half turn. They also argued that if the chain wheel turned once, the cogwheel would turn once as well. The third group was the qualitative strategy group which argued that the cogwheel would turn many times.

C POSSIBLE REASONS FOR STRATEGY USE

Performance was poor in this question, correct response being given by only 31% pre-test and 27% post-test. The estimated numbers of non guesses were much lower, only 12+9, about 11%. Learners who were choosing qualitative strategy were saying that they have seen a cogwheel turning many times after turning the chain wheel. This was a typical example of learners making use of their "alternative frameworks" to make sense of reality. These are knowledge frames that learners develop as a result of practical experience. These learners were showing a lack of understanding of more exact, quantitative relationships.

D TEACHING APPROACHES TO REMEDY THE SITUATION

The teaching approach needed to correct the situation would be a systematic training on proportion focussing on basic skills first, such as repeated addition. Oliver (1992) argued that repeated addition, which should lead to pattern-recognition of multiplicative relationships, should be developed in order to lay this necessary foundation, e.g.

Metres	centimetres	or	car	tyres
1	100	1	4	
2	200	2	8	
3	300	3	12	(p.310)

He further argued that children's build-up strategies should not be neglected

e.g. if 6 sweets cost 10c

3 sweets cost 5c

so 15 sweets cost 10c + 10c + 5c = 25c.

The introduction of these problems at a basic level of understanding would play a vital role in helping learners in developing skills needed to solve proportional problems.

QUESTION 4 PRE-TEST "DISTANCES"

A CODES AND STRATEGIES

codes	no.	answer		strategy
a	2	Blank		
b	31	D	180 min	Proportional strategy
c	10	A	110 min	Incomplete strategy
d	32	B	120 min	Incomplete strategy
e	20	C	100 min	Incomplete strategy

n=95

QUESTION 4 POST-TEST "DISTANCES"

CODES AND STRATEGIES

codes	no.	answer		strategy
a	1	Blank		
b	20	B	96 min	Proportional strategy
c	20	A	80 min	Incomplete strategy
d	11	C	88 min	Incomplete strategy
e	43	D	98 min	Qualitative strategy

n=95

B STRATEGIES IN USE FROM INTERVIEWS

Proportional strategy was used by learners in the form of repeated addition. Incomplete strategy was also used where learners ignored some aspect of data, e.g. learners stated that since the distance to the fifth town was 120 km, 120 minutes were needed to cover that distance. Qualitative strategy was also observed in the post-test. This was made possible by the fact that the distractors in the post-test were different from those in the pre-test and that prompted the appearance of another strategy which was not there in the pre-test. It should be noted that careful calculation was needed to get to the right answer in the post-test, whereas a qualitative strategy would work in the pre-test.

C POSSIBLE REASONS FOR STRATEGY USE

A decline in performance was observed in this question. Correct responses were only given by 32% in the pre-test and 22% in the post-test. Learners displayed a lack of basic skills in proportions. Additive skill was also lacking; this skill could have helped the learners in coping with the question.

D TEACHING APPROACHES TO REMEDY THE SITUATION

Helping learners at this level of development to cope with problems at a basic level skill on proportions would help. Helping learners in developing an additive strategy would be the right place to start. Once learners master the additive strategy with its shortcomings, they operate at a stage of pre-proportionality. Learners at this stage use additive strategies, but they do not use constant difference, e. g. 4 is to 8, 5 is to 10, and 6 is to 12. They have the intuition that the difference changes with the size of the number, but they do not yet realize that they need to consider a constantly increasing difference (Tourniaire and Pulos, 1985:187). Since the multiplication skills were important in this question, it would be argued that a possible explanation for the low attainment was a lack of this skill. Tourniaire (1986) in his study of proportional skills at elementary level, found a positive correlation between multiplicative skills and proportional skills (p.406).

QUESTION 5 PRE-TEST "ANNUAL RINGS"

A CODES AND STRATEGIES

codes	no.	answer	strategy
a	0	Blank	
b	32	A	Proportional strategy
c	19	B	Guess
d	27	C	Qualitative strategy
e	17	D	Incomplete strategy

QUESTION 5 POST-TEST "ANNUAL RINGS"

CODES AND STRATEGIES

codes	no.	answer	strategies
a	0	Blank	
b	43	C	Proportional strategy
c	15	A	Incomplete strategy

d	9	B	Guess
e	28	D	Incomplete strategy

B STRATEGIES IN USE FROM INTERVIEWS

Strategies which were in use in this question were, proportional strategy, qualitative strategy, incomplete strategy and clear guessing. Learners were looking at one part of data and ignoring the other part. "Any tree smaller than all the trees given would have more rings," said Sipho.

C POSSIBLE REASONS FOR STRATEGY USE

Lack of training in observation and misusing a correct strategy were behind this performance in this question, although there was some improvement. Correct responses were given by 34% in the pre-test and 46% in the post-test.

D TEACHING APPROACHES TO REMEDY THE SITUATION

It is important to develop skills in observation and expose learners to a lot of practical activity especially at grade 5 level where learners are still inept at using a variety of skills. The results shown above seem to indicate that strategies which were used by these learners, in trying to grapple with proportional problems, were not different from the strategies used by learners of the same age in other parts of the world. In a study conducted by Tourniaire (1986) in America with grade 5 learners on proportions, the results of that study (p.406) showed similar strategies which were in use, see TABLE IV below.

TABLE IV
Distribution of strategies (Tourniaire, 1986)

STRATEGY	INTERVIEW I	INTERVIEW II
No strategy	21	10
Additive strategy	6	9
Repeated addition	32	28
Correct	25	27
incorrect	7	1
Multiplicative strategy:	42	53
Correct	33	40
Incorrect	9	13
Total no. of pupils	180	120

Although the type of questions used determine the strategies to be used, strategies used by Tourniaire's learners were largely the same as those used by learners in this study. The only area of notable difference was a lower level of attainment in Khwezi pupils when dealing with the problems of this nature. The age of the learners used in Tourniaire's study is similar to that of the learners used by the researcher. They however differed in terms of family background, learning experiences and quality of teaching.

5.4 QUALITATIVE DATA ANALYSIS

Qualitative data was also recorded by the researcher after each and every lesson pertaining to the observations made during the learning process.

From the researcher's observation, Grade 5A which was experimental group I, had difficulties initially when trying to cope with the MAP based lessons. Learners were not familiar with group work, and the idea of working together as a group was also difficult to implement. Although the teacher was supposed to be monitoring them from a distance, it was not always the case and constant intervention was needed to ensure completion of the tasks in hand.

The strategy which was adopted by the researcher, faced with these difficulties, was to ensure the mastery of the learning technique first before delving into the subject matter. Initially most of the teacher's time was spent on organization but later on there was a gradual decline in this as the learners mastered the technique. This is the reason it sometimes seemed to the researcher that more time was spent on organization in Grade 5A than on actual teaching.

5.4.1 THE NEW TEACHING APPROACH

At first, Grade 5A seemed to make very little progress, and the researcher at some point felt that nothing would make an impact in changing the learning habits of these learners. Everything was being done to change their learning for the better, but the methods they were used to were hard to change. MAP lessons are also based on learning through activity where the teacher should model the activities for the learners. These learners were used to recitation, note-taking, reading from textbooks without understanding and reproducing as it was what the teachers had given. The shift that they were required to make was fundamental and it was a difficult process. Going through the activities was difficult since understanding of what was done was essential.

5.4.2 SCIENCE PROCESSES

Implementing classroom activities at grade 5 level with a learner-teacher ratio of 40 :1 is no mean feat. It was also difficult to get the learners to master the processes of science. They had to do a lot of observation e.g. looking at different components of the soil by mixing soil and water where all the parts separate according to different mass. They had to do a lot of comparison e.g. comparing loam soil, sandy soil ; inference e.g. tell the type of soil through water retention; they had to investigate e.g. which type of soil retains more water and also report on what they had been doing to the whole class. What was handicapping progress was the fact that all the other subjects were still using the old way of doing things and only general science was using this new method. Despite these problems, learners were slowly getting to grips with the new approach.

For the first time they were expected to trust others and learn from them. This was new to them, they only knew the teacher as the only source of information. To start listening to other learners and sharing their learning problems with them was a new experience. In some groups total silence prevailed and the researcher had to force the learners to talk. A lot of extrinsic motivation e.g. competition between groups had to be used in order to get the learners to participate in their groups. This was done with the hope that this form of motivation would at some point become intrinsic as they became more and more successful in doing their tasks.

5.4.3 LANGUAGE IN THE LEARNING PROCESS

The language factor in the whole exercise was critical in making the necessary difference. The learning approaches used in many of the second language medium schools are not amenable to the achievement of cognitive development. Instead of the language becoming a medium towards attainment of learning goals, it instead impedes learners in achieving those goals. Mcdonald (1993) in her study of private and state schools found that,

> *" Black children in the state system would keep finding that language-learning constraints interfere with concept learning. Their attention would inevitably be drawn to the form of what they are learning, rather*

than the underlying concepts and skills" (p.74).

MAP based lessons provided learners with opportunities for communication of ideas. It is only when learners are able to explain and also ask about concepts that they can truly claim mastery.

Mcdonald (1993) also wrote that children's oral skills are poorly developed, and show a high degree of grammatical error. There was generally little opportunity for learners to practise basic communication and their use of the subject-oriented English was stereotyped. This, she claimed, showed that they could not early free themselves of the forms their teachers, their notes and their textbooks imposed. She further wrote that the development of oral proficiency would be sensitive to the kinds of materials used - whether they promote interaction or not - and the opportunities they had to use English would be explicitly constrained by their teacher's management style (p.75).

McNaught (1991) in her study of science at the interface between Zulu and English argued that second language learners faced a lot of difficulties especially when concepts do not exist in the mother-tongue. Meaning needs to be negotiated with learners so that a consensus can be reached about useful, workable models of scientific phenomena.

McNaught further argued that strategies need to be developed to encourage useful discussion during science lessons. The strategies need to be based on much clearer knowledge about what is the nature of discussion which occurs between learners in science lessons. All of this supports the idea of providing learners with the opportunity to discuss, argue and articulate ideas so as to play a role in the process of constructing scientific knowledge in and outside the classroom.

Learners during lesson presentation marvelled at the opportunity of telling other class members about their experiences and their knowledge on specific aspects of the syllabus. When the new topics were introduced in class they were required to tell their group members and in some cases the whole class about their experiences. Mcdonald (1993) also pointed to the use of experiences, reflection on experiences and communication of experiences as a basis for understanding (p.92). She further pointed out that if the approach is of intrinsic interest to the learners, shows some relevance to the world in which learners live, and meaning in relation to ideas that the learners already have, more learners may be held for secondary science (p.94). The interest of the Khwezi learners in the subject became evident when they came out of the class, and the enthusiasm with which they approached their tasks showed that they were willing to be part of a process which held their knowledge and experiences in high regard.

Learners in Grade 5A started to involve themselves in the process of learning. They were now willing to participate, they were also willing to find out from practical experience, they were no longer afraid to ask if something was not clear to them and they enjoyed the opportunity of helping others in a group. Books were now used as a resource to support the learning process. Because of extrinsic motivation, e.g. creating competition among groups, there was now healthy support among group members. Sharing information on homework became important as a continuation of the learning process. Learners enjoyed the opportunity of working with their parents. However, some parents were not willing to assist at first but later they were also willing to help.

5.4.4 INTERVIEWS WITH GRADE 5 TEACHERS

Grade 5 science teachers were interviewed after the completion of the study about the Grade 5 classes and the progress that the learners were making. They were also asked to comment informally about their experiences with these classes. The teachers were quick to point out that although they do not use learner-centred methods often, it was apparent that when they did give learners work to do, Grade 5A produced the best. One teacher even exclaimed that, "When you ask them to work in groups you know that your work will be done". From these anecdotes it became apparent that given enough time and the necessary enthusiasm, MAP could have considersbly changed the learning experiences of the learners.

It was clear from the work presented in the worksheets that the groups were doing their best to succeed as a unit. The answers provided showed that the groups were working as units rather than as separate individuals. Learners were also encouraged to use their own words as much as possible when answering. Because of the continual practice in explaining to the next person, the idea of using one's own words in displaying one's understanding was also coming out very clearly from the work produced by the learners.

5.4.5 HOMEWORK

In looking at the homework done by learners, various patterns were emerging. There was a group which was still engaged in individual work, and there was also a group that was getting assistance from parents. Although it was clear that some parents were in fact telling the learners what to write, that on its own was important since it got the parents involved. Comparing the percentage of learners who did their homework in both groups, more than 50% of the learners were doing their homework in Grade 5A while in 5B less than 40% were doing it.

Grade 5B's lessons conformed to "normal" practice in that it was the teacher doing all the work for the learners. It was apparent that the learners were used to the technique since they were coping well. For the teacher, the lessons were easy to give since learners would sit down, fold arms and listen attentively to what the teacher was saying. They were not allowed to 'disturb' the teacher by asking questions; if ever they wanted to ask, the question would wait until the end of the lesson. Mostly, these learners were not given homework because, "*it's a waste of time, they will not do it, rather give them class work* ", said one teacher. The management style for Grade 5B was fairly simple, "give them whatever you are supposed to cover and do not worry about anything else". It was easy for the teacher since unlike in Grade 5A there were no problems to be solved all the time. Learners were behaving as 'normal' or as expected.

When looking at the video tapes and systematic observation schedules, the lessons were teacher-centred with no learner activity. The teachers were asked about this and they responded by saying that the learner-centred methods were difficult to handle due to large numbers in class, lack of resources, language problem, syllabus demands etc. Teachers were not seeing themselves as part of the problem. They were ready to blame others rather than look at their own practice.

The question of curriculum development needs to be discussed in our schools and workshops run on learner-centred pedagogy. It became apparent during the course of the discussion that teachers are not aware of what role they had to play. It also became clear that within the school, interdepartmental co-operation is lacking. Teachers are not aware what other departments are doing. This co-operation and integration is important especially at primary school level.

5.4.6 CONCLUSION

The results obtained in this study seemed to suggest that learners do have strategies that they use in solving problems. Their approaches in solving problems are intuitive in nature; as a result, they need development. The level of the skill under investigation was generally low. Errors that learners make at this level need to be known by teachers so as to use the information as a basis for instruction.

CHAPTER SIX: CONCLUSION

6.1 INTRODUCTION

This chapter provides a summary of both quantitative and qualitative results obtained during the course of the investigation. Limitations of this study are also presented and suggestions for further study are made. Implications for teaching are given which are important in that they challenge the teachers in the field to use this work in advancing the course of learner development at the primary level of schooling.

6.2 SUMMARY OF RESULTS

The results of this study seemed to suggest that many of the pupils tested showed a very low level on proportional reasoning skills. The mean scores for different groups were very low. This pattern of results was also observed in the post test in which some pupils performed even worse than in the pre-test. The results showed effectively no correlation between pupils' scores on the pre- and post-test. Many pupils who did well in the pre-test did not subsequently do well in the post-test. Very little gain was observed in the groups used in this study.

The results also showed that very little was achieved in developing the skill of proportional reasoning during the short period of the study. Other studies on the effects of training on proportional reasoning have also showed that narrow directed training is inadequate in teaching the concrete-operational child.

The study showed that pupils at grade 5 level do have strategies that they use in solving proportional problems. Strategies as outlined in Karplus et al. (1983) that were observed to be used by the learners were: proportional strategy additive strategy, incomplete strategy, qualitative strategy and guessing. The use of proportional strategies was observed in a small number of pupils' approach to the questions. It was also observed in this study that a lot of guessing happened although it was not the same in all questions.

The results also seemed to suggest that pupils were doing better when it came to problems that involved no numerical data. The direct opposite of this was observed when the problems involved numerical data. This has a lot of implications for teaching proportions at lower grade levels such as grades 5 and below.

The qualitative data gathered by the researcher showed a change of the roles pupils played in the learning process. The foundation for developing autonomous learners was being laid. Pupils were now taking part and playing the necessary role in the process of knowledge construction. This clearly demonstrated that given a chance, young pupils would be able to do much more than most do now.

6.3 LIMITATIONS OF THE STUDY

One major limitation of this study was the time factor. Three weeks were taken to complete the intervention programme and from the look of things, that time frame was not sufficient for the pupils, at this level of education, to master the new learning technique used in the classroom though they made substantial progress in this if not in proportional reasoning. Skill development requires enough time for pupils to go through the transition phase and master the new methodology which actually demands a lot from them.

The study involved a small group of pupils in a particular environment with specific set of circumstances. This circumscribed the level of generalization one would make regarding the use of the results obtained in this specific situation. The study could, however, be used to inform studies of this nature done in other situations.

6.4 SUGGESTIONS FOR FURTHER STUDY

Longitudinal application of the Means of Assisting Performance needs to be looked at very seriously since the limited time of intervention might have contributed towards the low achievement of class A. To implement MAP, assistance should not only be directed to one teacher and one class, but to the whole school from the assistant teacher to the principal of the school.

The approach in this study should be holistic and it should be school based, meaning that teachers in the school should take ownership of the whole programme and drive it in a direction they see fit since they have the practical experience of what would be required in each unique situation. This study has shown, through working with pupils, that appropriate assistance is essential for learning to happen and that it should be done in an integrated way.

Another area which needs further investigation is that of numerical skills and proportional reasoning. This area needs investigation in that it brings into question the nature of the relationship in schools between maths. and science and the form of co-operation, if any, that can exist between these two fields of learning. The role of integrated texts at this level needs to be investigated. Co-operation between subjects should not only be looked at in terms of the two subjects mentioned but in all subjects in the school curriculum.

One of the theories which underpinned this study was that of Piaget. Further studies need to be done on the operational levels of the pupils in the school in terms of Piaget's stages. Teachers need to know the general patterns of development so that they can structure their teaching accordingly. They need to know what pupils are capable of doing at the beginning of the year and also what they are able to do when they leave. The National Department of Education has proposed that by the year 2005 all school curricula up to Grade 9, including assessment, should be outcomes-based and this has implications for the type of teaching which will be needed in our schools. The changes required by this new approach are in close association with this study in which it became apparent that the restructuring of the teaching process is a necessity if teaching and learning are to be interfaced.

The results of this study have also indicated that learners come to school with a wealth of knowledge and experience that needs to be resourced and utilised. Pupils using intuitive knowledge were able to produce strategies that indicated a source of operational knowledge which usually is being overlooked. The study also demonstrated from a teaching point of view that whatever teachers say and ask would solicit a particular behaviour from the learners.

Teacher development is another of the critical areas which need to be looked at in our schools. If most of our teachers are still locked in the "recitation script" of previous years, what is being done to transform them? The role of teachers in a development programme needs to be spelled out. School-based development seems to be the ideal presently since it takes into cognisance the unique situation of a particular school.

Finally, the issue of the transfer of learning warrants further investigation in terms of the role played by context in the facilitation of transfer. The survey of literature showed very little research on primary science in South Africa especially among second language learners. The work of Mcdonald (1987) on the

Threshold project was revealing in that, it provided educators with some insight into what is happening at grade 5 level. More research work needs to be done at the primary level since it lays the foundation for later years of schooling.

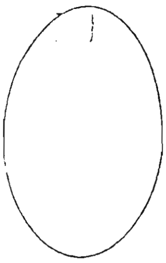
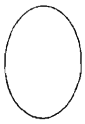
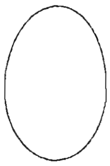
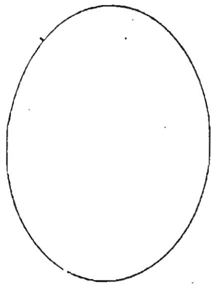
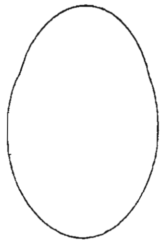
6.5 IMPLICATIONS FOR TEACHING

The findings of this study can be applied to the content as well as the timing of proportional problems. Teaching of proportions should not be delayed until grade 7, as is the case now, but an early start at a basic level of understanding would help the learners a great deal. Strategies that learners use in solving proportional problems should be investigated so that they are developed and become the basis of what needs to be done. The work done by Tourniaire (1986) on proportions supports this view when he argues that children begin to handle proportional problems situations intuitively and informally (in Oliver (1992) p.297). The focus should be on introducing the skill and using as little numerical data as possible. Complicated problems should be delayed until higher grades.

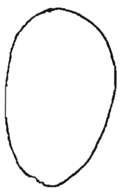
APPENDIX I
PROPORTIONAL SKILLS TEST
PRE-TEST GRADE FIVE

QUESTION 1

The table below shows eggs of five birds and the number of days each egg takes to hatch.

	Wild Duck	Robin	Blackbird	Golden Eagle	Crow
					
Usual number of days to hatch	30	13	14	40	19

A chicken's egg is this size:



How long will this egg take to hatch?

Put a cross next to the correct answer.

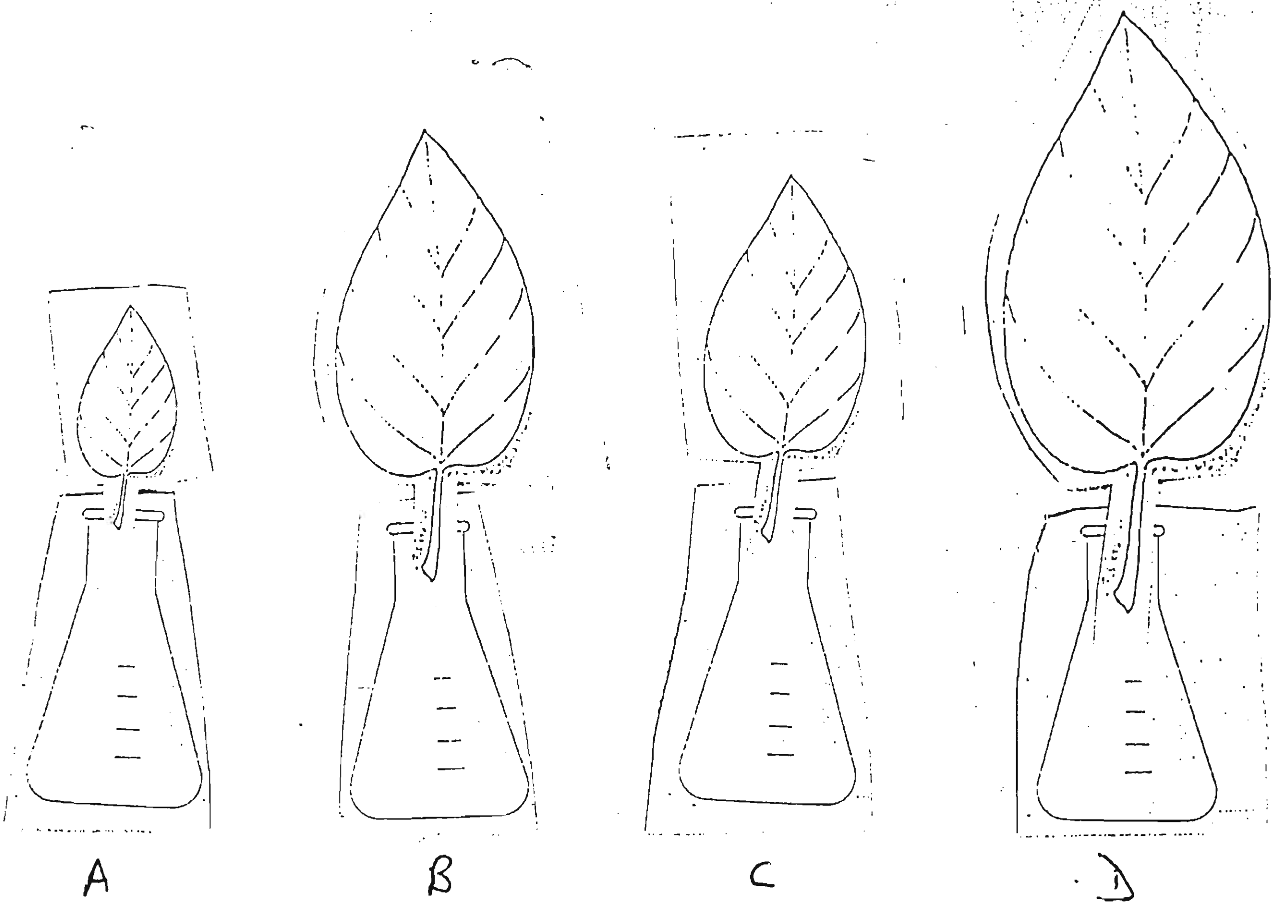
A. 14 Days

B. 30 Days

C. 19 Days

D. 21 Days

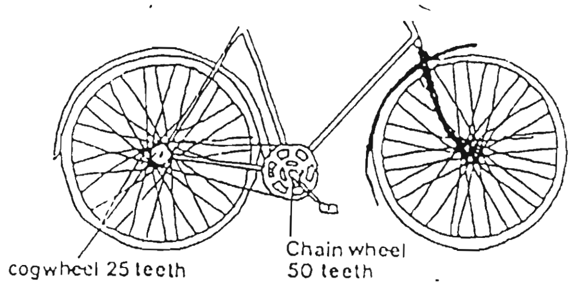
QUESTION 2



Thandi was trying to find out how leaves of different sizes lost water. She started by putting these leaves into beakers with same amount of water. She began to see that the biggest of all the leaves was loosing more water.

Put a cross under the beaker with a leaf that lost the smallest amount of water.

QUESTION 3



Look at the diagram above very carefully.

On this bicycle there are 50 teeth on the chainwheel and 25 teeth on the cogwheel in the middle of the back wheel.

If you turn the chainwheel once, how many times will the cogwheel turn?

Put a cross next to the correct answer.

A. Half turn

B. Once

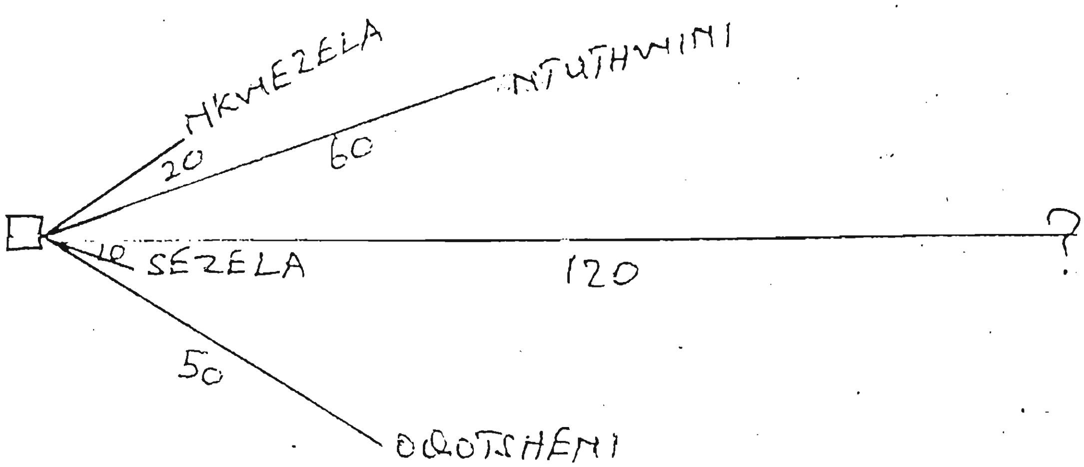
C. 2 turns

D. 5 turns

E. 10 turns

QUESTION 4

Look carefully at the diagram below.



Look at the following table.

TOWN	DISTANCE FROM PIETERMARITZBURG	TIME TAKEN FOR ONE TRIP TO PMB
NKWEZELA	20 KM	16 MINUTES
NTUTHWINI	60 KM	48 MINUTES
SEZELA	10 KM	08 MINUTES
OQOTSHENI	50 KM	40 MINUTES

There is another town not in this table. It is about 120 km from Pietermaritzburg. How long do you think it would take to travel from this town to Pietermaritzburg?
Put a cross next to the correct answer.

A. 80 minutes

B. 96 minutes

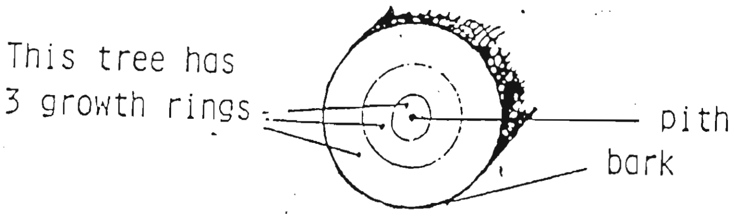
C. 88 minutes

D. 98 minutes

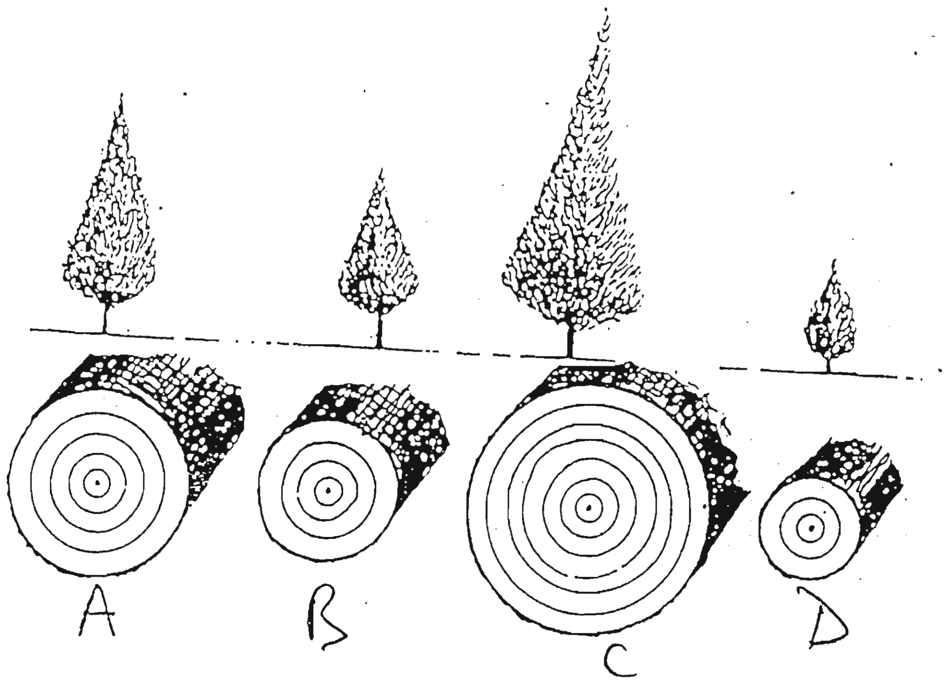
QUESTION 5

Look carefully at the following diagrams.

When we cut across the trunk of a tree we see growth rings.



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



In the same wood there is another tree. It is taller than any of the trees shown above. Do you think it would have more or less rings than the trees shown above? Put a cross next to the correct answer.

A. More rings than tree C.

B. Fewer rings than tree A.

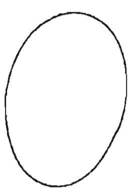
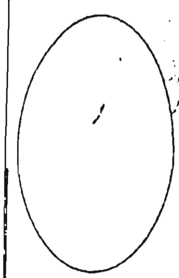
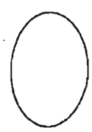
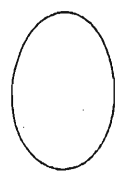
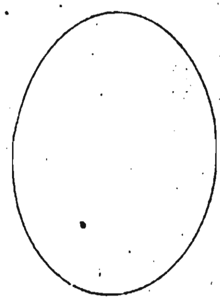
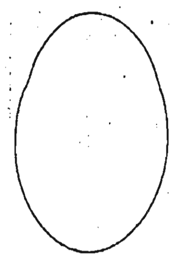
C. The same number of rings as tree C.

D. Less rings than tree C but more rings than tree A.

APPENDIX II
PROPORTIONAL SKILLS TEST
POST-TEST GRADE FIVE

QUESTION 1

The table below shows eggs of five birds and the mass of each egg.

Fowl	Wild Duck	Robin	Blackbird	Golden Eagle	Crow
					
	39	23	33	43	38

What do you think is the mass of the fowl's egg?

Put a cross next to the correct answer.

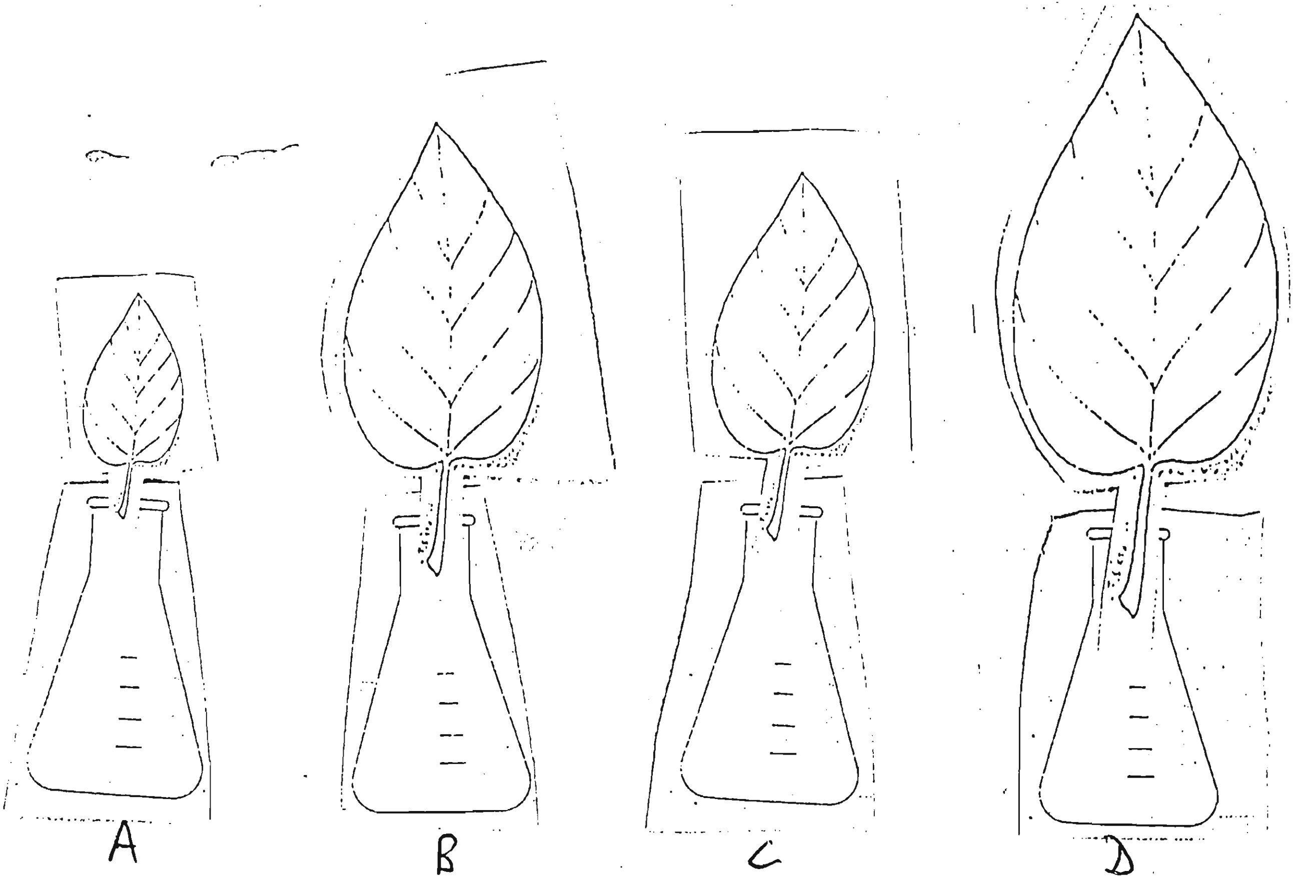
A. 33g

B. 38g

C. 43G

D. 39G

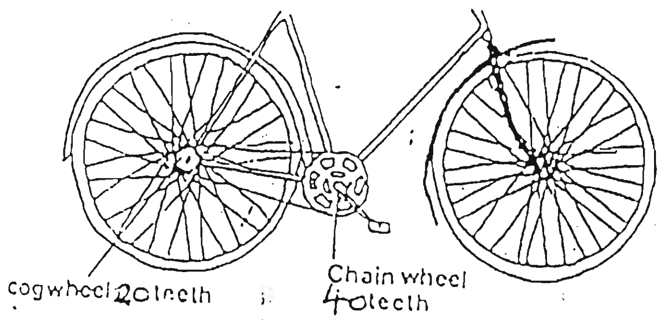
QUESTION 2



Mandla was trying to find how leaves of different sizes lost water. He started by putting these leaves into beakers with same amount of water. He began to see that the smallest of all the leaves was loosing less water.

Put a cross under the beaker with a leaf that lost the highest amount of water.

QUESTION 3



Look at the diagram above very carefully.

On this bicycle there are 40 teeth on the chainwheel and 20 teeth on the cogwheel in the middle of the back wheel.

If you turn the chainwheel once, how many times will the cogwheel turn?

Put a cross next to the correct answer.

A. Half turn

B. Once

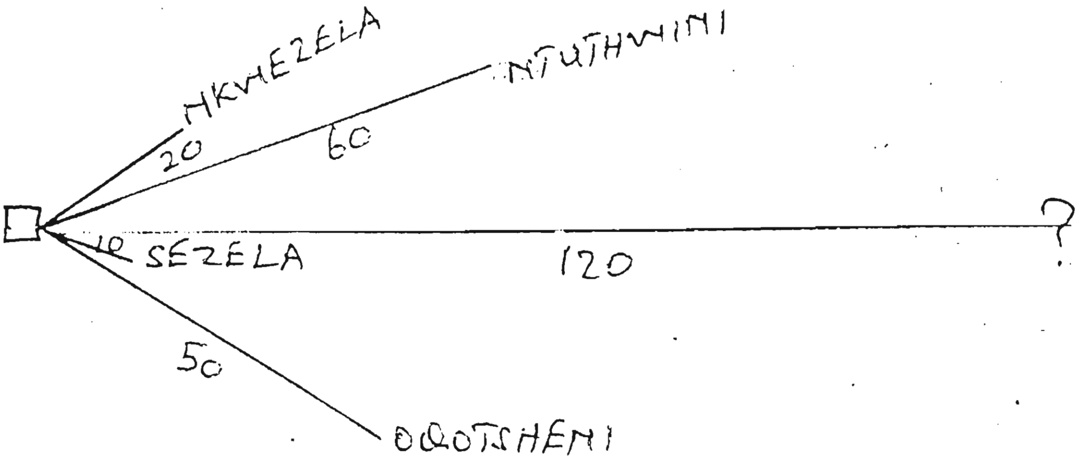
C. 2 turns

D. 5 turns

E. 10 turns

QUESTION 4

Look carefully at the diagram below.



Look at the following table.

TOWN	DISTANCE FROM PIETERMARITZBURG	TIME TAKEN FOR ONE TRIP TO PMB
NKWEZELA	20 KM	16 MINUTES
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SEZELA	10 KM	08 MINUTES
OQOTSHENI	50 KM	40 MINUTES

There is another town not in this table. It is about 120 km from Pietermaritzburg. How long do you think it would take to travel from this town to Pietermaritzburg?
Put a cross next to the correct answer.

A. 80 minutes

B. 96 minutes

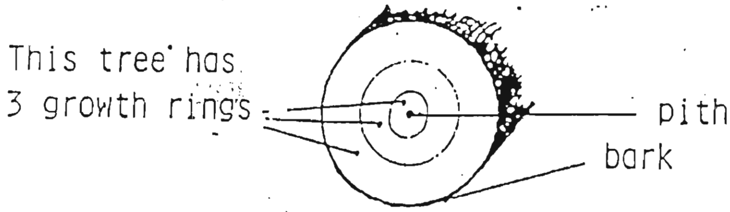
C. 88 minutes

D. 98 minutes

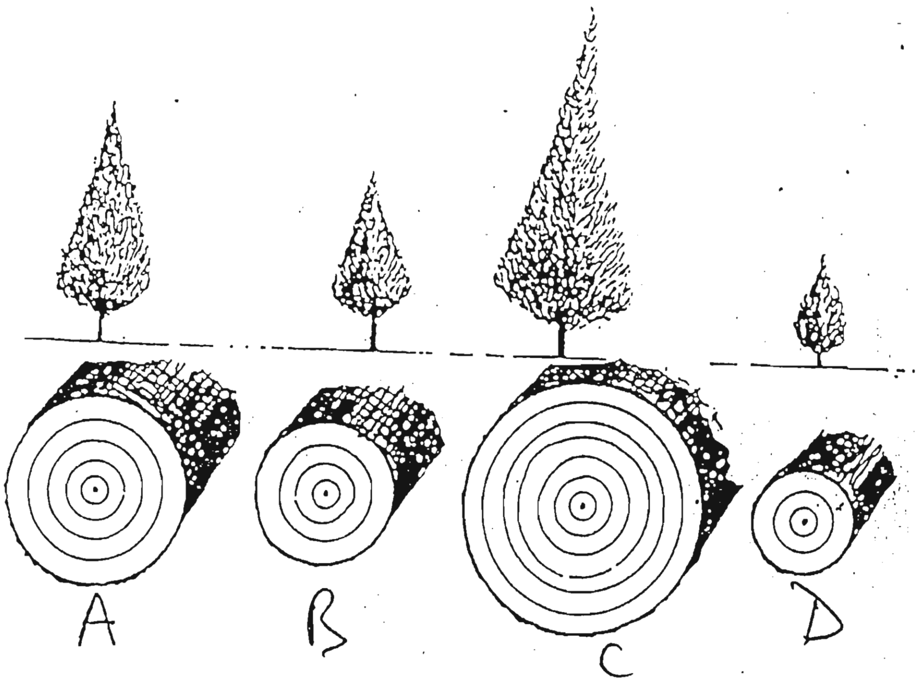
QUESTION 5

Look carefully at the following diagrams.

When we cut across the trunk of a tree we see growth rings.



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



In the same wood there is another tree. It is smaller than any of the trees shown above. Do you think it would have more or less rings than the trees shown above? Put a cross next to the correct answer.

A. More rings than tree D.

B. More rings than tree C.

C. Less rings than tree D.

D. Same rings as tree B.

APPENDIX III

ESTIMATED NUMBER OF GUESSES AND NON-GUESSES ASSUMING THAT SOME PUPILS COULD DO THE QUESTIONS AND ALL THE OTHERS GUESSED RANDOMLY AMONG OPTIONS PROVIDED

QUESTION 1 PRE-TEST

CODES	NO.
a	0
b	41
c	21
d	15
e	18

Estimation of no. of Guesses
Total no. of wrong answers
21+15+18 = 54

54 divided by 3 = 18
Estimate 18 guesses for b
Estimated total no. of guesses =
54+18=72

Estimated no. of Non-guesses
41-18 = 23

QUESTION 1 POST-TEST

CODES	NO.
a	4
b	44
c	17
d	15
e	11

GUESSES
Total no. of wrong answers
17+15+11 = 43

43 divided by 3 = 14
Estimate 14 guesses for b
Estimated total no. of guesses =
43+14 = 57

NON-GUESSES
44-14 = 30

QUESTION 2 PRE-TEST

CODES	NO.
a	0
b	56
c	06
d	02
e	29

Random guessing hypothesis clearly inappropriate in this question, as nearly all pupils choose only two options.

QUESTION 2 POST-TEST

CODES	NO.
a	0
b	55
c	37
d	03

Random guessing hypothesis also inappropriate, as nearly all pupils chose only two options.

e 01

QUESTION 3 PRE-TEST

CODES	NO.	Estimation of no. of Guesses	Estimated no. of Non-guesses
a	0	Total no. of wrong answers	29-17=12
b	29	13+19+21+15 = 68	
c	13	68 divided by 4 = 17	
d	19	Estimate 17 guesses for b	
e	21	Estimated number of guesses=	
f	15	68+17 = 85	

QUESTION 3 POST-TEST

CODES	NO.	Estimation of no. of Guesses	Estimated no. of Non-guesses
a	01	Total no. of wrong answers	26-17=9
b	26	13+24+21+11 = 69	
c	13	69 divided by 4 = 17	
d	24	Estimate 17 guesses for b	
e	21	Estimated number of guesses =	
f	11	69+17 = 86	

QUESTION 4 PRE-TEST

CODES	NO.
a	01
b	31
c	10
d	32
e	20

Random guessing hypothesis questionable, very unequal spread among options.

QUESTION 4 POST-TEST

CODES	NO.
a	01
b	22
c	20
d	11
e	43

Random guessing hypothesis also questionable, very unequal spread among options.

QUESTION 5 PRE-TEST		Estimation of no. of	Estimated no. of
CODES	NO.	Guesses	Non-guesses
a	0	Total no. of wrong answers	32-21=11
b	32	19+27+17 = 63	
c	19	63 divided by 3 = 21	
d	27	Estimate 21 guesses for b	
e	17	Estimated Total no. of guesses = 63 + 21 = 84	

QUESTION 5 POST-TEST		Estimation of no. of	Estimated no. of
CODES	NO.	Guesses	Non-guesses
a	0	Total no. of wrong answers	44-17=27
b	44	15+09+28 = 52	
c	15	52 divided by 3 = 17	
d	09	Estimate 17 guesses for b	
e	28	Estimated Total no. of guesses = 52+17 = 69	

A very uneven spread meant that the random guessing hypothesis was questionable.

APPENDIX IV

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: Khwezi PRIMARY

Teacher: ....

Observer: S.S. MEMELA

Date: 13:03:96

Topic: PHASES OF MATTER

Standard: THREE

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle															
	2.	TEACHER:	asks pupils to recall fact and principle	X														
	3.	TEACHER:	asks pupils to recall by rephrasing			X												
	4.	PUPIL:	recalls statement of fact or principle (R)		X													
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)				X											
	7.	TEACHER:	translates Zulu statement into English						X									
	8.	TEACHER:	repeats statement												X			
	9.	TEACHER:	asks pupils for English translation					X								X		
	10.	PUPILS:	attention ensured (T/P)							X								
	11.	PUPIL:	drill answer (T/P)														X	
	12.	CLASS:	drill answer (T/C)															
	13.	TEACHER:	rewards accurate recall								X							
	14.	TEACHER:	corrects pupil answer															X
	15.	TEACHER:	makes statement of problems															
	16.	TEACHER:	makes statement of hypothesis															
	17.	TEACHER:	makes statement of exp procedure															
	18.	TEACHER:	directs pupils to self-evident activity									X						
	19.	PUPILS:	involved in self-evident activity (eg copying)										X					
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data															
	2.	TEACHER:	asks pupil for novel examples											X				
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations															
	8.	TEACHER:	asks the pupils (15) for interpretation															
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions															
	12.	TEACHER:	asks the pupils (19) to give explanations															
	13.	PUPILS:	use the senses to gather information															
	14.	PUPILS:	identify differences/similarities															
	15.	PUPILS:	interpreting of observed or recorded data															
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: IKWEZI PRIMARY

Teacher: ....

Observer: S.S. MEMELA

Date: 14.08.96

Topic: CONDENSATION

Standard: THREE

Category	No.	Actor	Behaviour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle															
	2.	TEACHER:	asks pupils to recall fact and principle	X														
	3.	TEACHER:	asks pupils to recall by rephrasing															
	4.	PUPIL:	recalls statement of fact or principle (R)		X													
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)			X												
	7.	TEACHER:	translates Zulu statement into English										X					
	8.	TEACHER:	repeats statement								X							
	9.	TEACHER:	asks pupils for English translation									X						
	10.	PUPILS:	attention ensured (T/P)															
	11.	PUPIL:	drill answer (T/P)															
	12.	CLASS:	drill answer (T/C)				X											
	13.	TEACHER:	rewards accurate recall															
	14.	TEACHER:	corrects pupil answer															
	15.	TEACHER:	makes statement of problems															
	16.	TEACHER:	makes statement of hypothesis															
	17.	TEACHER:	makes statement of exp procedure					X										
	18.	TEACHER:	directs pupils to self-evident activity						X									
	19.	PUPILS:	involved in self-evident activity (eg copying)						X									
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data															
	2.	TEACHER:	asks pupil for novel examples															
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations											X				
	8.	TEACHER:	asks the pupils (15) for interpretation												X			
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions															
	12.	TEACHER:	asks the pupils (19) to give explanations															
	13.	PUPILS:	use the senses to gather information													X		
	14.	PUPILS:	identify differences/similarities														X	
	15.	PUPILS:	interpreting of observed or recorded data															X
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: KHWEZI PRIMARY

Teacher: ....

Observer: ....

Date: 18-03-96

Topic: WATER CYCLE

Standard: THREE

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER: makes statement of fact and principle	X														
	2.	TEACHER: asks pupils to recall fact and principle								X							
	3.	TEACHER: asks pupils to recall by rephrasing											X				
	4.	PUPIL: recalls statement of fact or principle (R)										X					
	5.	CLASS: recalls statement of fact or principle (R)												X			
	6.	PUPIL(S): repeat statement of fact or principle (P/C)									X						
	7.	TEACHER: translates Zulu statement into English		X													
	8.	TEACHER: repeats statement			X												
	9.	TEACHER: asks pupils for English translation															
	10.	PUPILS: attention ensured (T/P)														X	
	11.	PUPIL: drill answer (T/P)															
	12.	CLASS: drill answer (T/C)															X
	13.	TEACHER: rewards accurate recall															
	14.	TEACHER: corrects pupil answer				X											
	15.	TEACHER: makes statement of problems															
	16.	TEACHER: makes statement of hypothesis					X										
	17.	TEACHER: makes statement of exp procedure						X									
	18.	TEACHER: directs pupils to self-evident activity															
	19.	PUPILS: involved in self-evident activity (eg copying)							X								
PROCESS-THINKING SKILLS	1.	TEACHER: asks pupil to support belief with data															
	2.	TEACHER: asks pupil for novel examples															
	3.	TEACHER: asks pupil for counter examples															
	4.	TEACHER: asks pupil about viability of examples															
	5.	TEACHER: looking at alternatives (material/procedure)															
	6.	TEACHER: directs pupils towards practical crit. activity															
	7.	TEACHER: asks the pupils to make direct observations										X					
	8.	TEACHER: asks the pupils (15) for interpretation															
	9.	TEACHER: asks the pupils (16) for inference															
	10.	TEACHER: asks the pupils (17) application of fair test															
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	13.	PUPILS: use the senses to gather information															
	14.	PUPILS: identify differences/similarities															
	15.	PUPILS: interpreting of observed or recorded data															
	16.	PUPILS: making inferences from observations or data															
	17.	PUPILS: applying facts or principles to problem-solving															
	18.	PUPILS: trying to explain a phenomenon (analysis)															
	19.	PUPILS: ask questions for information															
	20.	PUPILS: ask questions for clarification															
	21.	PUPILS: offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS: seek guidance from teacher on materials etc.															
	2.	PUPILS: report or explain actions to teacher.															
	3.	PUPILS: organising task co-operatively: Zulu															
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	5.	PUPILS: talk off the topic															
	6.	PUPILS: work independently in group situation															
	7.	PUPILS: talk about the task: Zulu															
	8.	PUPILS: talk about the task: English															
	9.	PUPILS: maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: ..KHANFZI..................

Teacher: ....

Observer: ....

Date: 19.03.96..........

Topic: DAST FOR WATER

Standard: ....THREE.........

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle															
	2.	TEACHER:	asks pupils to recall fact and principle		X													
	3.	TEACHER:	asks pupils to recall by rephrasing															
	4.	PUPIL:	recalls statement of fact or principle (R)			X												
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)				X											
	7.	TEACHER:	translates Zulu statement into English					X										
	8.	TEACHER:	repeats statement															
	9.	TEACHER:	asks pupils for English translation											X				
	10.	PUPILS:	attention ensured (T/P)															
	11.	PUPIL:	drill answer (T/P)															
	12.	CLASS:	drill answer (T/C)												X			
	13.	TEACHER:	rewards accurate recall															
	14.	TEACHER:	corrects pupil answer													X		
	15.	TEACHER:	makes statement of problems															
	16.	TEACHER:	makes statement of hypothesis										X					
	17.	TEACHER:	makes statement of exp procedure														X	
	18.	TEACHER:	directs pupils to self-evident activity						X									
	19.	PUPILS:	involved in self-evident activity (eg copying)															X
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data															
	2.	TEACHER:	asks pupil for novel examples															
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations	X														
	8.	TEACHER:	asks the pupils (15) for interpretation							X								
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions								X							
	12.	TEACHER:	asks the pupils (19) to give explanations															
	13.	PUPILS:	use the senses to gather information									X						
	14.	PUPILS:	identify differences/similarities															
	15.	PUPILS:	interpreting of observed or recorded data															
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: ...[illegible]...

Teacher: ....

Observer: ....

Date: 20:03:96

Topic: SOURCES OF HEAT

Standard: THREE

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle					X										
	2.	TEACHER:	asks pupils to recall fact and principle												X			
	3.	TEACHER:	asks pupils to recall by rephrasing													X		
	4.	PUPIL:	recalls statement of fact or principle (R)															
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)															
	7.	TEACHER:	translates Zulu statement into English														X	
	8.	TEACHER:	repeats statement						X									
	9.	TEACHER:	asks pupils for English translation															X
	10.	PUPILS:	attention ensured (T/P)											X				
	11.	PUPIL:	drill answer (T/P)															
	12.	CLASS:	drill answer (T/C)															
	13.	TEACHER:	rewards accurate recall															
	14.	TEACHER:	corrects pupil answer															
	15.	TEACHER:	makes statement of problems															
	16.	TEACHER:	makes statement of hypothesis								X							
	17.	TEACHER:	makes statement of exp procedure															
	18.	TEACHER:	directs pupils to self-evident activity															
	19.	PUPILS:	involved in self-evident activity (eg copying)															
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data									X						
	2.	TEACHER:	asks pupil for novel examples							X								
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations	X														
	8.	TEACHER:	asks the pupils (15) for interpretation															
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions															
	12.	TEACHER:	asks the pupils (19) to give explanations				X											
	13.	PUPILS:	use the senses to gather information		X													
	14.	PUPILS:	identify differences/similarities			X												
	15.	PUPILS:	interpreting of observed or recorded data															
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: KHMIER

Teacher: ....

Observer: ....

Date: 23.07.96

Topic: EXPANSION/CONTRACTION-SOLID

Standard: THREE

Section	No.		Behaviour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle	X														
	2.	TEACHER:	asks pupils to recall fact and principle										X					
	3.	TEACHER:	asks pupils to recall by rephrasing															
	4.	PUPIL:	recalls statement of fact or principle (R)															
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)												X			
	7.	TEACHER:	translates Zulu statement into English													X		
	8.	TEACHER:	repeats statement														X	
	9.	TEACHER:	asks pupils for English translation															
	10.	PUPILS:	attention ensured (T/P)															
	11.	PUPIL:	drill answer (T/P)															X
	12.	CLASS:	drill answer (T/C)															
	13.	TEACHER:	rewards accurate recall															
	14.	TEACHER:	corrects pupil answer															
	15.	TEACHER:	makes statement of problems							X								
	16.	TEACHER:	makes statement of hypothesis															
	17.	TEACHER:	makes statement of exp procedure								X							
	18.	TEACHER:	directs pupils to self-evident activity															
	19.	PUPILS:	involved in self-evident activity (eg copying)									X						
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data															
	2.	TEACHER:	asks pupil for novel examples															
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations		X													
	8.	TEACHER:	asks the pupils (15) for interpretation			X												
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions															
	12.	TEACHER:	asks the pupils (19) to give explanations				X											
	13.	PUPILS:	use the senses to gather information					X										
	14.	PUPILS:	identify differences/similarities															
	15.	PUPILS:	interpreting of observed or recorded data						X									
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: KHAMARI

Teacher: ....

Observer: ....

Date: 26:03:96

Topic: EXPANSION/CONTRACTION - GAS

Standard: THREE

				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER:	makes statement of fact and principle									X						
	2.	TEACHER:	asks pupils to recall fact and principle										X					
	3.	TEACHER:	asks pupils to recall by rephrasing															
	4.	PUPIL:	recalls statement of fact or principle (R)												X			
	5.	CLASS:	recalls statement of fact or principle (R)															
	6.	PUPIL(S):	repeat statement of fact or principle (P/C)															
	7.	TEACHER:	translates Zulu statement into English								X							
	8.	TEACHER:	repeats statement											X				
	9.	TEACHER:	asks pupils for English translation													X		
	10.	PUPILS:	attention ensured (T/P)															
	11.	PUPIL:	drill answer (T/P)															
	12.	CLASS:	drill answer (T/C)						X									
	13.	TEACHER:	rewards accurate recall														X	
	14.	TEACHER:	corrects pupil answer							X								
	15.	TEACHER:	makes statement of problems															
	16.	TEACHER:	makes statement of hypothesis															
	17.	TEACHER:	makes statement of exp procedure															
	18.	TEACHER:	directs pupils to self-evident activity															X
	19.	PUPILS:	involved in self-evident activity (eg copying)															
PROCESS-THINKING SKILLS	1.	TEACHER:	asks pupil to support belief with data															
	2.	TEACHER:	asks pupil for novel examples															
	3.	TEACHER:	asks pupil for counter examples															
	4.	TEACHER:	asks pupil about viability of examples															
	5.	TEACHER:	looking at alternatives (material/procedure)															
	6.	TEACHER:	directs pupils towards practical crit. activity															
	7.	TEACHER:	asks the pupils to make direct observations	X														
	8.	TEACHER:	asks the pupils (15) for interpretation		X													
	9.	TEACHER:	asks the pupils (16) for inference															
	10.	TEACHER:	asks the pupils (17) application of fair test															
	11.	TEACHER:	asks the pupils to make predictions															
	12.	TEACHER:	asks the pupils (19) to give explanations			X												
	13.	PUPILS:	use the senses to gather information															
	14.	PUPILS:	identify differences/similarities				X											
	15.	PUPILS:	interpreting of observed or recorded data															
	16.	PUPILS:	making inferences from observations or data															
	17.	PUPILS:	applying facts or principles to problem-solving															
	18.	PUPILS:	trying to explain a phenomenon (analysis)															
	19.	PUPILS:	ask questions for information															
	20.	PUPILS:	ask questions for clarification															
	21.	PUPILS:	offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS:	seek guidance from teacher on materials etc.															
	2.	PUPILS:	report or explain actions to teacher.															
	3.	PUPILS:	organising task co-operatively: Zulu															
	4.	PUPILS:	organising group co-operatively: English															
	5.	PUPILS:	talk off the topic															
	6.	PUPILS:	work independently in group situation															
	7.	PUPILS:	talk about the task: Zulu															
	8.	PUPILS:	talk about the task: English															
	9.	PUPILS:	maintain focus of discussion															

040

ADDENDUM

COST: CLASSROOM OBSERVATION OF SCIENCE TEACHING

School: KHAYELI... PRIMARY

Teacher: ....

Observer: ....

Date: 15.03.96

Topic: EVAPORATION

Standard: THREE

Category	No.	Behaviour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TEACHER-CENTRED	1.	TEACHER: makes statement of fact and principle	X														
	2.	TEACHER: asks pupils to recall fact and principle															
	3.	TEACHER: asks pupils to recall by rephrasing															
	4.	PUPIL: recalls statement of fact or principle (R)															
	5.	CLASS: recalls statement of fact or principle (R)															
	6.	PUPIL(S): repeat statement of fact or principle (P/C)															
	7.	TEACHER: translates Zulu statement into English															
	8.	TEACHER: repeats statement															
	9.	TEACHER: asks pupils for English translation															
	10.	PUPILS: attention ensured (T/P)															
	11.	PUPIL: drill answer (T/P)						X									
	12.	CLASS: drill answer (T/C)														X	
	13.	TEACHER: rewards accurate recall															X
	14.	TEACHER: corrects pupil answer							X								
	15.	TEACHER: makes statement of problems															
	16.	TEACHER: makes statement of hypothesis					X										
	17.	TEACHER: makes statement of exp procedure															
	18.	TEACHER: directs pupils to self-evident activity															
	19.	PUPILS: involved in self-evident activity (eg copying)															
PROCESS-THINKING SKILLS	1.	TEACHER: asks pupil to support belief with data															
	2.	TEACHER: asks pupil for novel examples															
	3.	TEACHER: asks pupil for counter examples															
	4.	TEACHER: asks pupil about viability of examples															
	5.	TEACHER: looking at alternatives (material/procedure)															
	6.	TEACHER: directs pupils towards practical crit. activity															
	7.	TEACHER: asks the pupils to make direct observations		X													
	8.	TEACHER: asks the pupils (15) for interpretation			X												
	9.	TEACHER: asks the pupils (16) for inference															
	10.	TEACHER: asks the pupils (17) application of fair test															
	11.	TEACHER: asks the pupils to make predictions															
	12.	TEACHER: asks the pupils (19) to give explanations				X											
	13.	PUPILS: use the senses to gather information								X							
	14.	PUPILS: identify differences/similarities									X						
	15.	PUPILS: interpreting of observed or recorded data										X					
	16.	PUPILS: making inferences from observations or data															
	17.	PUPILS: applying facts or principles to problem-solving															
	18.	PUPILS: trying to explain a phenomenon (analysis)															
	19.	PUPILS: ask questions for information															
	20.	PUPILS: ask questions for clarification											X				
	21.	PUPILS: offers clarification															
PUPIL GROUP BEHAVIOUR	1.	PUPILS: seek guidance from teacher on materials etc.															
	2.	PUPILS: report or explain actions to teacher.															
	3.	PUPILS: organising task co-operatively: Zulu												X			
	4.	PUPILS: organising group co-operatively: English															
	5.	PUPILS: talk off the topic															
	6.	PUPILS: work independently in group situation															
	7.	PUPILS: talk about the task: Zulu													X		
	8.	PUPILS: talk about the task: English															
	9.	PUPILS: maintain focus of discussion															

ADDENDUM

t: CLASSROOM OBSERVATION OF SCIENCE TEACHING

ool: KHYHERI

cher: ....

erver: ....

Date: 25:03:96

Topic: EXPANSION/CONTRACTION-LIQUID

Standard: THREE

TEACHER-CENTRED

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	TEACHER: makes statement of fact and principle							X								
2.	TEACHER: asks pupils to recall fact and principle								X							
3.	TEACHER: asks pupils to recall by rephrasing															
4.	PUPIL: recalls statement of fact or principle (R)															
5.	CLASS: recalls statement of fact or principle (R)															
6.	PUPIL(S): repeat statement of fact or principle (P/C)															
7.	TEACHER: translates Zulu statement into English											X				
8.	TEACHER: repeats statement										X					
9.	TEACHER: asks pupils for English translation															
10.	PUPILS: attention ensured (T/P)									X						
11.	PUPIL: drill answer (T/P)												X			
12.	CLASS: drill answer (T/C)															
13.	TEACHER: rewards accurate recall															
14.	TEACHER: corrects pupil answer													X		
15.	TEACHER: makes statement of problems															
16.	TEACHER: makes statement of hypothesis														X	
17.	TEACHER: makes statement of exp procedure															
18.	TEACHER: directs pupils to self-evident activity															X
19.	PUPILS: involved in self-evident activity (eg copying)															

PROCESS-THINKING SKILLS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	TEACHER: asks pupil to support belief with data															
2.	TEACHER: asks pupil for novel examples															
3.	TEACHER: asks pupil for counter examples															
4.	TEACHER: asks pupil about viability of examples															
5.	TEACHER: looking at alternatives (material/procedure)															
6.	TEACHER: directs pupils towards practical crit. activity															
7.	TEACHER: asks the pupils to make direct observations	X														
8.	TEACHER: asks the pupils (15) for interpretation		X													
9.	TEACHER: asks the pupils (16) for inference															
10.	TEACHER: asks the pupils (17) application of fair test															
11.	TEACHER: asks the pupils to make predictions															
12.	TEACHER: asks the pupils (19) to give explanations			X												
13.	PUPILS: use the senses to gather information				X											
14.	PUPILS: identify differences/similarities					X										
15.	PUPILS: interpreting of observed or recorded data															
16.	PUPILS: making inferences from observations or data															
17.	PUPILS: applying facts or principles to problem-solving															
18.	PUPILS: trying to explain a phenomenon (analysis)						X									
19.	PUPILS: ask questions for information															
20.	PUPILS: ask questions for clarification															
21.	PUPILS: offers clarification															

PUPIL GROUP BEHAVIOUR

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	PUPILS: seek guidance from teacher on materials etc.															
2.	PUPILS: report or explain actions to teacher.															
3.	PUPILS: organising task co-operatively: Zulu															
4.	PUPILS: organising group co-operatively: English															
5.	PUPILS: talk off the topic															
6.	PUPILS: work independently in group situation															
7.	PUPILS: talk about the task: Zulu															
8.	PUPILS: talk about the task: English															
9.	PUPILS: maintain focus of discussion															

REFERENCES

Anderson, J.R. (1990). Cognitive psychology and its implications (3rd ed). New York: Freeman.

Ausubel, D.P. (1968). Educational Psychology: A cognitive view. New York: Holt, Rinehart and Winston, Inco.

Bandura, A. (1977). Social learning theory. Englewood Cliffs, NJ: Prentice-Hall.

Bennett, N. (1976). Teaching styles and pupil progress. London: Open Books Publishing Ltd.

Bliss, J. (1995). Piaget and after: the case of learning science. Studies in Science Education, 25, pp.139-172.

Boulanger, F.D. (1976). The effects of training in the proportional reasoning associated with speed. Journal of Research in Science Teaching, Vol.13, No.2, pp.145-154.

Bredderman, T. (1983). The effects of activity-based elementary science on students outcomes: a quantitative synthesis. Review of Educational Research, Vol.53, No.4, pp.499-518.

Brophy, J. (1993). Research linking teacher behaviour to student achievement: Potential implications for instruction of chapter I students. Educational Psychology, Vol 23, No.3, pp.235-276.

Bruner, J. (1993). Child's talk: learning to use language. New York: Norton.

Buck-Morss, S. (1975). Socio-economic bias in Piaget's theory and its implications for cross culture studies. Human Development, Vol.18, pp.35-49.

Case, R. (1984). 'The process of stage-transition: a neo-Piagetian view' , in R.J. Stenberg (ed) Mechanism of cognitive development. New York: Freeman.

Cloutier, R. and Goldschmid, M.L. (1978). Training proportionality through peer instruction. Instructional Science, Vol.7, pp.127-142.

Croll, P. (1986). Social research and educational studies series: 3. Systematic classroom observation. London: Falmer Press.

Davis, N.T., McCarthy, J.B., Shaw, L.K. and Siddani-Tabbaa, A. (1993). Transition from objectivism to constructivism in science education. International Journal of Science Education, Vol. 5, No.6, pp.627-636.

Delamont, S. (1976). 'Beyond Flanders Fields', in Stubbs, M. and Delamont, S. (Eds) Exploration. Chichester: Wiley.

Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. Harvard Educational Review, Vol.58, pp.280-298.

Department of Education (1995). White paper on education and training. Government Gazette. Cape Town.

Diaz, R.M. (1986). The union of thought and language in children's private speech. Quarterly Newsletter of the Laboratory of Comparative Human Cognition, Vol.8, No.3, pp90-97.

Driver, R. & Easley, J. (1978). Pupils and paradigms: a review of literature related to concepts development on adolescent scince students. Studies in Science Education, Vol.5, pp.61-84.

Driver, R. (1983). The pupil as scientist. Milton Keynes, Open University Press.

Driver, R., Brook, A. and Johnston, K. (1984). Beyond processes and content. in Wellington, J. (ed) (1989). Skills and processes in science education. London:Routledge.

Driver, R., Guesne, E., & Tiberghien, A. (1985). Children's ideas in science. Milton Keynes, England: Open University Press.

Driver, R. & Oldham, V. (1986). A constructivist approach to curriculum development in science. Studies in Science Education, Vol.13, pp.105-122.

Duckworth, D. (1972). The choice of science subjects by grammar school pupils. Ph.D. thesis: Univ. of Lancaster.

Edwards, D. & Mercer, N. (1987). Common knowledge: The development of understanding in the classroom. London: Methuen.

Eggleston, T.F., Galton, M. and Jones, M.E. (1976). A science teaching observation schedule. London: Macmillan.

Flanders, N.A. (1970). Analysing teacher behaviour. Cambridge, MA, Addison-Wesley.

Fortes, M. (1938). Education in Tableland Africa, 11 (Supplement 4), pp.14-74.

Freire, P. (1970/1989). Pedagogy of the oppressed. New York: Continuum (Originally published by Herder & Herder, New York).

Gilbert, J.K. & Watts, D.M. (1983). Concepts, misconceptions and alternative conceptions: changing perspectives in science education studies. Studies in Science Education, Vol.10, pp.61-98.

Glaser, R. (1984). Education and thinking: The role of knowledge. American Psychologist, Vol.39, pp.93-104.

Gold, A.P. (1978). Cumulative learning versus cognitive development: a comparison of two different theoretical bases for planning remedial instruction in arithmetic. Unpublished PhD dissertation, University of California, Berkeley.

Good, T.L. and Brophy, J.E. (1978). Looking in classrooms (2nd ed.). Harper and Row, New York.

Greenfield, P.M. (1984). A theory of the teacher in the learning activities of everyday life. In B. Rogoff & J. Lave (Eds.), Everyday cognition: Its development in social contexts (pp.117-138). Cambridge, MA: Harvard University Press.

Harlen, W. (1992). The teaching of science. London, Fulton.

Harlen, W., Black, P. and Johnston, S. (1981). Science in schools: assessment of performance unit, age 11: Report no.1. London: Her Majesty's Stationery Office.

Hart, K.M. (1981). Children's understanding of mathematics: 11-16. John Murray Ltd, London.

Heller, P.M., Ahlgren, A., and Post, J.C. (1989). Proportional reasoning: The effect of two context variables, rate type, and problem setting. Journal of Research in Science Teaching, Vol.26, No.3, pp.205-220.

Hodson, D. (1990). A critical look at practical work in school science. School Science Review, Vol.70, No.256, pp.33-40.

Hopkins, D. (1985). A teacher's guide to classroom research. Milton Keynes, Open University Press.

Howe, A.C. (1996). Development of science concepts within a Vygotskian Framework. Science Education: Vol.80, No.1, pp.35-51.

HSRC (1981). Investigation into education. Pretoria, Human Sciences Research Council.

Inhelder, B. and Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. New York: Basic books.

Jenkins, E.W. (1985). Processes in science education: a historical perspective. In Wellington, J. (ed) (1989). Skills and processes in science education. London: Routledge.

Kahn, M. and Rollnick, M. (1993). Science education in the new South Africa: reflections and visions. International Journal of Science Education, Vol.15, No.3,pp.261-272.

Karplus, R., Pulos, S. and Stage, E.K. (1983). Proportional reasoning of early adolescents: In R. Lesh and M.Landau (eds.), Acquisition of mathematics concepts and processes. New York: Academic Press.

Keil, F.C. (1979). Semantic and conceptual development. Cambridge, Mass.: Harvard University Press.

Kelly, P.J. (1959). An investigation of factors influencing grammar school pupils to prefer science subjects. MA dissertation, Univ. of London.

Kieren, T.E. and Southwell, B. (1979). 'The development in children and adolescents of the construct of rational numbers as operators'. The Aberta Journal of Educational Research,Vol.25, No.4, pp.234-247.

Kraak, A. (1989). New insights into the skills shortage debate in South Africa. Perspectives in Education, 11, pp.19-36.

Kyle, W.C. & Bonnstetter, R.J. (1987). Implementation and evaluation of an exemplary science: program report, Richardson Independent School District, USA.

Kyle, W.C., Bonnstetter, R.J., Gadsen, T. & Shymansky,.T.A. (1988). What research says...about hands on science. Science and Children, Vol 25, No.7, pp.39-40.

Lawson, A.E. and Wollman, W.T. (1975). 'Cognitive level, cognitive style and value judgement'. Science Education, Vol.61, No.3, pp397-407.

Linn, M.C. and Pulos, S. (1983). 'Aptitude and experiences' influence on proportional reasoning during adolescence: focus on male-female differences'. Journal for Research in Mathematics Education, Vol.14, No.1, pp30-46.

Mcdonald, C.A. (1987). Standard three general science report - A final report of the Threshold project. Pretoria: Human Sciences Research Council.

Mcdonald, C.A. (1993). Towards a new Primary Curriculum in South Africa- Main report of the Threshold Project 2. H Pretoria: Human Sciences Research Council.

McNaught, C. (1991). Learning science at the interface between Zulu and English: A brief overview of research issues in this area. Paper delivered at the conference 'Language Thought and Culture', Johannesburg.

Meadows, S. (1993). The child as thinker: the development and acquisition of cognition in childhood. London: Routledge.

Millar, R. (1989). Doing science: images of science in science education. Lewes: Falmer Press.

Morris, H. (Ed) (1996). Understanding the National Qualifications Framework: A guide to lifelong learning. Johannesburg: Independent Examination Board.

Muller, R. (1987). Establishing what counts as an explanation in science discourse: case studies in South African High schools. Unpublished M.Ed Thesis. Johannesburg: University of Witwatersrand.

Munting, J. (1991). Problem areas for hands-on work in general science in standard 3 to 5. South African Journal of Education, Vol.11, No.3, pp152-157.

National Science Board (1983). Commission on precollege education in mathematics, science and technology. Educating America for the 21st century. Washington: National Science Foundation.

Noelting, G. (1980). The development of proportional reasoning and the ratio concept: Part I - Differentiation of stages. Educational Studies in Mathematics, Vol, 11, pp.217-253.

Novak, J.D. (1978). Editorial comment on 'implications of Piagetian research for high school science teaching: review of the literature. Science Education, Vol.62, No.4, pp.591-592.

Oliver, A.T. (1992). Developing proportional reasoning. In Moodley, M., Njisane, R.A. and Presmeg, N.C. (1992). Mathematics Education for In-service and Pre-service Teachers. Pietermaritzburg: Shuter and Shooter.

O'Loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. Journal of Research in Science Teaching Vol.29, No.8, pp.791-820.

Osborne, R. and Wittrock, M. (1985). 'The generative learning model and its implications for science education', Studies in Science Education. Vol.12, pp.54-87.

Perkins, D.N. and Salomon, G. (1989). Are cognitive skills context-bound? Educational Researcher, Vol.18, No.1, pp.16-25.

Piaget, J. (1970). Piaget's theory. In P.H. Musson (Ed): Carmichael's manual of child psychology. New York: Wiley.

Piaget, J. (1977). Intellectual evolution from adolescence to adulthood. In P. N. Johnson-Laird and P.C. Wason (Eds), Thinking: Readings in cognitive science. Cambridge, Cambridge University Press.

Pulos, S., Karplus, R., and Stage, E.K. (1981). 'Generality of proportional reasoning in early adolescents; Content effects and individual differences. Journal of Early Adolescence, Vol.1, pp.257-264.

Redelinghuis, R.B., Hitchcock, I. and Bason, N.J.S. (1980). General Science for today. Johannesburg: Juta.
Resnick, L.B. (1983). Mathematics and science learning: A New Conception. Science, Vol.120, pp.477-488.

Screen, P. (1986). Warwick process science. London: Ashford Press.

Shymansky, J.A., Kyle, W.C., & Alport, J.M. (1983). Effects of new science curricula on student performance. Journal of Research in Science Teaching, Vol.20, No.5, pp387-404.

Siegel, L.S. (1978). The relationship of language and thought in the pre-operational child: a reconsideration of non-verbal alternatives to Piagetian tasks. In L.S. Siegel and C.J. Brainerd (eds): Alternatives to Piaget. New York: Academic Press.

Siegler,R.S. (1976). Three aspects of cognitive development. Cognitive psychology, Vol.8, pp.481-520.

Siegler, R.S. (1983). Information processing approaches to development. In W. Kessen (ed.). Handbook of child psychology, Vol.1. Series ed. P.H. Mussen. New York: Wiley.

Stor-Hunt, M.P. (1996). An analysis of frequencies of hands on experience and science achievement. Journal of Research in Science Teaching, Vol.33, No. 1, pp.101-109.

Tharp, R. & Gallimore, R. (1988). Rousing minds to life: teaching, learning, and schooling in social context. United Kingdom: Cambridge University Press.

Tharp, R.G., Jordan, et al. (1984). Production and process in applied developmental research: education and the children of a minority. In M.E. Lamb, et al. (Eds.): Advances in Developmental Psychology. Vol.3, pp.91-144. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Tharp, R.G. and Wetzel, R. (1969). Behaviour modification in the natural environment. New York: Academic Press.

Tobin, K. (1988). Active teaching for higher cognitive learning in science. International Journal of Science Education, Vol.10, No.1, pp.17-27.

Tobin, K., Espinet, M., Byrd, S.E., and Adams, D. (1988). Alternative perpectives of effective science teaching. Science Education, Vol.72, No.4, pp.433-451.

Tourniaire, F. and Pulos, S. (1985). Proportional reasoning: a review of the literature. Educational Studies in Mathematics, Vol.16, pp.181-204.

Tourniaire, F. (1986). Proportions in elementary school. Educational Studies in Mathematics, 17, pp. 401-412.

Vergnaud, G. (1979). 'The acquisition of arithmetical concepts'. Educational studies in mathematics, Vol.10, pp.263-274.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Watson, D.R. and Tharp, R.G. (1988). Self-directed behaviour (5th ed.). Monterey, CA: Brooks/Cole.

Wersan, N. (1981). Utilising a self-generated visual art strategy to facilitate proportional problem solving in mathematics. Unpublished doctoral dissertation, Rutgers University.

Wertch, V.J. (1981). The voice of rationality in a sociocultural approach to mind. In Moll, L.C. (ed) (1990). Vygotsky and education: instructional implications and applications of sociohistorical psychology. USA: Cambridge University Press.

Wilson, N.J. (1979). 'The ethnographic style of research'. In Block I (Variety in social science research), Part I (Styles of Research) of Open University Course DE 304, Research methods in education and social sciences. Milton Keynes, Open University Press.

Yager, R.E. (1983). Toward a model for K-12 science education. Paper presented at the American Association for the Advancement of Science meeting, Detroit, MI. 26-31 May 1983. In Bonnstetter, R.J., Penink, J.E. & Yager, R.E. Teachers in exemplary programs: how do they compare? Washington: National Science Teacher Association.

Yager, R.E. (1985). The present status of science education in the USA. Paper presented at 11th National Convention for Secondary and Primary School Teachers of Mathematics, Physical Science and Biology. Durban: University of Durban-Westville, 1-5 July.

Yager, R.E. (1991). The consructivist learning model. The Science Teacher, pp.52-57.

Zinchenko, V. (1989). Is science an integral part of culture? Impact of Science on Society. Vol.39, No.155, pp.253-265.