AN INVESTIGATION INTO NATURAL SCIENCES EDUCATORS'PERCEPTIONS AND PRACTICES OF CLASSROOM ASSSSMENT: A CASE STUDY OF THE GRADE EIGHT EDUCATORS IN THE PIETERMARITZBURG REGION.

ETHEL-MARIA TERRESAH KHOLIWE
NKABANE

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DECLARATION

I hereby declare that this whole dissertation, unless specifically indicated to the contrary, is my original work.

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ETHEL. M. T. K. NKABANE (MISS)

DATE: 2004 JUNE 30.

ABSTRACT

The aim of this study was to investigate Grade eight (8) Natural Science educators' assessment classroom practices and their perceptions about assessment.

This study was based on the theory of a hierarchy of knowledge and skills that underpins the Revised National Curriculum Statement for Natural Sciences. An assumption was made that if assessment practices are to promote learning, as conceived in Curriculum 2005, educators' assessment practices must reflect a hierarchy of knowledge and skills.

The educators' perceptions and their assessment practices were explored in the light of how learning is conceived to take place in the Revised National Curriculum Statement for Natural Sciences, i.e. learning is conceptualised as a "process". It was on this basis that an "accumulative" nature of learning was perceived as a relevant theoretical framework informing this study, i.e. learning ranges from simple to complex capabilities.

To facilitate the educator's assessment practices and perceptions, a qualitative and quantitative approach was adopted. Interview schedules, observations and document analysis instruments were used as a means of collecting relevant data.

The interview schedule included questions that elicited educators' biographies, perceptions the educators hold in relation to a hierarchy of knowledge and skills and the perceptions the educators hold about assessment. The observation schedule and the document analysis instrument were based on Gagne's hierarchy of knowledge and skills. These skills are discrimination learning, concept learning, rule learning and problem solving learning.

The sample consisted of four Grade eight Natural Sciences educators drawn from four high schools in the greater Pietermaritzburg district. Three of these educators were from well-resource urban schools and one was from a poorly resourced Imbali Township.

Interviews, documents and observations were analysed in terms of a hierarchy of knowledge and skills as a research framework informing the study. The results show that all the respondents assessed concrete and concept categories more frequently than the rules and problem- solving categories. This assessment strategy was common in both oral and written assessment tasks.

The results exposed some inconsistencies between the educators' perceptions and their assessment practices. All four educators have unclear perceptions of the notion of a hierarchy of knowledge and skills, while in practice a wide range of categories of knowledge and skills were used in assessment tasks.

The findings led to the conclusion that the policy needs to be explicit about the fact that the expected assessment standards within each learning outcome are organised around the notion of a hierarchy of knowledge and skills. This will make it clear to science educators why assessment should form an integral part of learning. In- service programmes are necessary to sensitise educators about organising assessment practices on the basis of a hierarchy of knowledge and skills.

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CHAPTER ONE

1.1 INTRODUCTION.

This chapter provides a background and overview of the study. The chapter begins with a brief background to the study, and goes on to a detailed description of the research problem and theoretical framework informing the study. The main purpose of the study was to investigate Grade 8 Natural Science Educators' perceptions and practices of assessment in classroom settings.

1.2 BACKGROUND TO THE STUDY.

Learning in Science is hierarchical, that is, it ranges from simple to complex tasks. Gagne, (1970: 256) states that:

"The hierarchy of capabilities that is learned when an individual learns science has several features in common with learning of mathematics".

Gagne (1970) identifies intellectual skills in science learning as ranging from discrimination, concepts, rules and problem solving. Learning as operating within a hierarchical spectrum is also evident in Bloom (1964) and Piaget's (1964) conceptualisation of learning. Blooms' (1964) cognitive hierarchical stages range from knowledge, comprehension and application to synthesis and analysis. Piaget's (1964) theory of learning, which is based on a hierarchy of intellectual skills/capabilities, is widely recognised in learning science. For example, Bennett (2003) states that:

"Piaget's stage theory of development has had a particular impact on science and mathematics education because there is considerable overlap between some of the cognitive abilities associated with each of Piaget's stages and abilities which schools science and mathematics seek to develop." (pp53-54).

Piaget's (1964) hierarchical cognitive stages range from pre-operational through concrete operational to formal operational thinking. Gagne (1968) is explicit about the notion of a hierarchy, as he states that:

"Knowledge consists of sets of subordinate capabilities called learning sets which are arranged in a hierarchy. Each learning set may have several other learning sets subordinated to it. Together the subordinate learning sets mediate positive transfer to the learning set of the next higher order in the hierarchy. If one or more of the subordinate learning sets is not present/cannot be recalled, transfer to the next higher order of learning set is predicted to be zero" (pp177).

If assessment is to be an integral part of science learning as conceived in Curriculum 2005, assessment practices have to be developed on the basis of a hierarchy of knowledge and skills. The Revised National Curriculum Statement for Natural Sciences Grade R-9 supports a hierarchical view of knowledge and skills in science.

For example, arrangement of learning outcomes is underpinned by a hierarchy of knowledge and skills. Science investigation as learning outcome one extends from Grade R to 9. Learners will be engaged with concrete things, manipulate and experiment environment throughout the General Education and Training band. In Gagne's terminology, this will be discrimination learning which is equivalent to concrete operational developmental stage in Piaget's terminology. The construction of knowledge as learning outcome two and Science, Society and environment as learning outcome three only starts from Grade 4. Learners will be engaged with intellectual skills. In Gagne's (1992) terminology, this will be rule, concept and problem- solving skills equivalent to the formal operational developmental stage in Piaget's (1964) terminology.

This study focuses on a hierarchy of knowledge and skill. A hierarchical organisation of knowledge and skills is evident in learning outcome two. For example recalling meaningful information and categorisation of information is expected from Grade 4 to through Grade 9 while interpretation of information begins in Grade 6. Application of knowledge to problems is added in Grade 7.

Assessment practice as reflected in the Revised National Curriculum Statement for Natural Sciences must be conducted in terms of a hierarchy of assessment standards, if assessment is to be an integral part of learning in science. Therefore an educator's assessment tasks must reflect this hierarchy. For successful implementation of the Revised National Curriculum Statement for Natural Sciences, educators must be knowledgeable about hierarchies of knowledge and skills in science. Knowledge about hierarchies of skills will enable the educators to be specific about what they are assessing. Hierarchical knowledge will enable the educators to know the level the learners have reached/ are ready to reach. The big questions asked in this study are:

1. Are science educators knowledgeable about the notion of hierarchy?

2. What perception do science educators hold in relation to a hierarchical view of knowledge and skills?

3. To what extent are educator's assessment perceptions and practices guided by a theory premised on the hierarchy of knowledge and skills?

If Curriculum 2005 emphasizes integration and continuous assessment, suggesting a progress-driven curriculum, it follows that assessment practices in Natural Sciences must conform to curriculum expectations. One would expect educators' assessment practices to reflect the notion of a hierarchy of knowledge and skills.

1.3 THE RESEARCH PROBLEM AND THE RATIONALE FOR THE STUDY.

My argument builds on the report of the Review Committee in Chisholm (2000) where statement is made that Curriculum 2005 is being driven by the notion of integration of knowledge and skills, and does not make allowance for conceptual coherence, which is necessary within disciplines like Mathematics and Natural Sciences. Chisholm (2000) argues that:

"But, because the main concern of designers has been to foreground integration, there has been an under-specification of requirements for conceptual coherence across all eight learning areas. Where learning areas with distinctive conceptual coherence requirement are driven mainly by integration requirement, then the potential for conceptual progression is retarded" (pp 41-42).

Conceptual coherence, sequence and progression suggest that learning is developmental and is underpinned by a notion of hierarchy of knowledge and skills. If assessment practices are meant to be an integral part of learning and teaching, it stands to reason that they have to recognise conceptual coherence, sequence and progression of knowledge, and hence should be based and influenced by a hierarchical view of knowledge and skills. Chisholm (2000:42) cites negligence and under-specification of conceptual coherence and progression in fields like Natural Science and Mathematics as having a disabling effect in these fields. If under-specification of conceptual coherence, sequence and progression exist in these fields, yet these remain a necessity, I perceive this under-specification to have the potential to cripple assessment practices.

If learning is conceptualised as developmental, that is, subordinate capabilities must be learned prior the super ordinate ones, then learning in this sense recognises conceptual coherence, sequencing and progression of knowledge and skills, which suggests a hierarchy of knowledge and skills. Assessment practices in Natural Sciences must be developed on the basis of a hierarchy of knowledge and skills. The development of assessment tasks in this way will recognise that learning ranges from simple to complex tasks.

If a learner is assessed relative to his/her level of development, then this implies that an educator has to look at learner achievements relative to himself/herself as opposed to specified norms or performances of other learners. This will mean assessing a learner in terms of what he/she is ready to do/can do, rather than in standards set by an educator (Gipps, 1994). Assessment focused on the learner rather than educator's expectations is helpful in that it gives feedback to the learner and to the educator of the level of learning that has been achieved.

Conceptualisation of assessment practices in this way suggests recognition of developmental stages of a learner. Fairbrother (1988) argues that assessment practices will have to explore evidence of the development of processes/procedures, while also recognising understanding of scientific content.

The above argument raises the question of alignment between the curricular expectations, teaching and learning and what is being assessed. One of the claims made about classroom assessment is that it has to promote learning (Hodson, 1993). In fields like Natural Sciences where conceptual coherence, sequencing and progression are necessary, and learning is conceived to range from simple tasks to complex tasks, classroom assessment practices must be sensitive to a hierarchical order of knowledge and skills to promote learning in this field. This study attempted to explore the extent to which educators in their assessment practices and perception were guided by a theory premised on the hierarchy of knowledge and skills.

1.4. THEORETICAL FRAMEWORK INFORMING THE STUDY.

This study drew on Gagne's theory of learning as a complex phenomenon (Bell-Gredler 1986). Gagne (1992) holds that what accounts for complex learning is its "diverse" and "cumulative" nature. With reference to the "diverse nature of learning" Gagne (1970) conceptualises learning as composed of different categories, while the "cumulative" nature of learning is accounted for by an accumulation of simple intellectual skills as the basis for attainment of complex intellectual skills. I have adopted this theoretical framework on the basis that the Revised National Curriculum Statement for Natural Sciences Grade R-9 is underpinned by the notion of a hierarchy of knowledge and skills.

This study investigates the "cumulative" nature of learning rather than the "diverse" nature of learning since the "cumulative" nature of learning reflects a vertical hierarchy of knowledge and skills. The "cumulative" nature of learning as conceptualised by Gagne (1992) is relevant in fields like Natural Science where certain concepts must be mastered before other concepts.

In science learning, educators have to be knowledgeable about which capabilities are likely to precede others. Being knowledgeable about the hierarchy of knowledge and skills enables assessment practices to support learning. Assessment practices that recognise the hierarchy of knowledge and skills will support learners in their learning experiences, since the educators will realise the extra support that is necessary to the learner. Assessment tasks must reflect a hierarchy of knowledge and skills. This will enable early identification of problems experienced by the learner, and will provide opportunities for rectifying these problems timeously, so as to help the learner to accomplish complex tasks. The detailed description of Gagne's (1992) conceptualisation of learning will be discussed in chapter two, highlighting the propositions he made about learning as a complex phenomenon.

Learning hierarchies are defined by Gagne (1985) as "*psychological organisation of intellectual skills, composed of sets of rules where one or more concepts may be prerequisite to the learning of single rules, similarly, two or more rules may be prerequisite to the learning of subordinate rules*" (pp28). Gagne (1985) states that acquiring the entire set of rules in this way form a learning hierarchy that describe a route to attainment of organized sets of intellectual skills that represent 'understanding' of the topic. This hierarchical view of knowledge and skills was perceived to be critical in fields like Natural Sciences where conceptual coherence, sequencing and progression are a prerequisite. Educators' assessment tasks must therefore reflect the hierarchy of knowledge and skills.

1.5 DEFINITION OF CONCEPTS.

The definitions given below are attempts to clarify the use of terms in the study and to illustrate current trends.

1.5.1 Psychometric Assessment.

Gipps (1994) defines a psychometric mode of assessment as an attempt to measure attributes which are properties of an individual and which are thought to be fixed. Psychometric assessment practices are an attempt to interpret scores in relation to norms, in which an individual's performance is graded in relation to that of his/her peers (pp 5).

1.5.2 Educational Assessment.

In contrast to psychometric assessment, educational assessment aims to assess an individual as an individual rather than in relation to other individuals, and to use measurement constructively to identify strengths and weaknesses individuals might have so as to aid their educational progress (Gipps 1994: pp 8).

Glaser (1990) cited in Gipps (1994) outlines the benefits of using educational assessment practices both for the learner and the educator, as he states that this kind of assessment must offer advice to both learner and the teacher in which knowledge is assessed in terms of its constructive use for further action. Once mastered, the skills and knowledge of a domain should be viewed as enabling competencies for the future. Glaser (1990) makes the case that this assessment mode must be used to support learning rather than just to indicate current or past achievements.

1.5.3 Assessment as An Integral Part Of Learning.

Bennett (2003) identifies assessment as an integral part of learning as formative, since it aims to establish progress and diagnose learning needs in order to support individuals. Bennett (2003) argues that this approach is associated with pupils' development.

1.5.4 Hierarchy of Knowledge and Skills.

From the psychological point of view learning that ranges from simple to complex tasks is a hierarchy of knowledge and skills (Gagne1970). From the science point of view a hierarchy of knowledge and skills is perceive to range from general skills to specific skills or vice versa (Woolnough, 1991). At a general level, skills that involve open-ended problem solving skills, involve many skills but these are not clearly defined. Therefore, assessment of problem-solving skills becomes difficult. At a specific level, problems are more directed and skills are clearly defined, criteria are clear and assessment is easier.

1.5.5 Understanding the Concept "Process Skills"

Woolnough (1991) defines processes, as the various ways of thinking that will be needed to co-ordinate the pupils conceptual and procedural understanding in an overall plan for the task. Learners will use and develop concepts while utilising and refining the procedural elements of the task. Woolnough (1991) believes that effective teaching in science requires that we develop activities which motivate and encourage children to make use of their skills of observing, classifying, hypothesising and predicting as a means of exploring and coming to an understanding of scientific ideas and concepts. In teaching science, while teaching processes is necessary, learners have to be helped to use those processes to develop conceptual understanding.

Process skills are thought to be general and specific in science. For example, process skills that are general are skills like observing, classifying, inferring, hypothesising, and predicting (cognitive skills). These are thought to be transferable to real life situations and the learner uses these skills in solving practical problems, as Levinson (1994) states that by making these processes the focus of instruction, pupils will develop general skills, which they can apply to new problems in new areas either within science or beyond. Here we are concerned about scientific observing, classifying, inferring, and hypothesising in science (specific skills) (Levinson 1994).

Other than general and specific skills, craft skills need to be taught in science. Craft skills include the ability to handle apparatus, assemble apparatus, take appropriate measurements. Levinson (1994) states that science has a characteristic way of working, characteristic standards of judgement and appraisal. Doing science is more like the skilful exercise of a repertoire of craft skills than following an algorithm, (Levinson 1994).
"*Doing science is like practising a craft and this of course, has implications for the way science and scientific enquiry can be done*" (Levinson, 1994: pp 167).

1. 5.6. Declarative and Procedural Knowledge.

Novak (2002:553) describes declarative knowledge (conceptual knowledge) as the knowledge where we "*know that*" about something, whereas procedural knowledge he describes as the knowledge where we "*know how*" something works.

1.5.7 Structure of The Dissertation.

Following this introductory chapter, which outlines the background to the study, the research problem and the rationale for the study, the theoretical framework adopted in this study, a literature review will be undertaken in chapter two. This will involve an in-depth discussion of the hierarchical view of knowledge and skills as a research framework in this study, scientifically worthwhile knowledge and skills as perceived by scientists, views of scientific knowledge as the basis for scientific assessment practices, new policies on assessment in the South African context.

Highlighting some gaps that exist in the literature will conclude chapter two. Chapter three outlines the research design and the methodological procedures followed in this study. In chapter four the analysis of results will be the primary theme. Chapter five will focus on the discussion and the interpretation of these findings, linking them to the theoretical background reviewed earlier. Chapter six will contain a discussion of limitations and recommendations of the study and will contain conclusions to the study.

CHAPTER TWO: LITERATURE REVIEW.

2.1 INTRODUCTION

The aim of this chapter is to provide a theory pertinent to a hierarchy of knowledge and skills as the basis for this study. This will be followed by a discussion of what constitutes scientifically worthwhile knowledge and skills. New policies on assessment in South Africa will be explored as this forms the basis of this study. This will be followed by views of scientific knowledge as the basis for scientific assessment practices. Finally an attempt will be made to explore some gaps in the literature. In this way the researcher intends to provide a contextually sensitive framework to locate the study.

2.2 Hierarchical View of Knowledge And Skills As a Research Framework.

This section attempts to broaden the understanding of the hierarchical view of knowledge and skills by drawing from Gagne's (1970) perception and comparing it with Bloom, Davis, and Hass, (1956) taxonomy of educational objectives, in order to arrive at the perspective that informs the study. Piaget's (1964) cognitive developmental stages will be discussed since they are applicable to science learning as well. Since this study draws heavily on Gagne's theory of learning as a complex phenomenon (Bell-Gredler 1986: 121), it is necessary to first highlight Gagne's conceptualisation of learning as a complex phenomenon.

2.2.1 Gagne and Blooms' conceptualisation of learning as a complex phenomenon: A hierarchy of knowledge and skills.

This study is based on the hierarchy of knowledge a skills as outlined by Gagne (1970). Gagne (1970) proposes that complex learning is characterised by its diverse nature i.e. learning is composed of different categories therefore in any learning task a learner may acquire a variety of capabilities. Gagne (1970) further proposes that learning progresses from simple to complex tasks i.e. he holds a hierarchical view of knowledge and skills. Gagne (1970) suggests that learning is cumulative *i.*e. for a learner to accomplish complex tasks he must have acquired a number of lower-level capabilities.

Gagne's (1970) conceptualisation of learning as a complex phenomenon is shared by Bloom (1956). In both theorists the diverse nature of learning, its cumulative nature, and a hierarchical view of knowledge and skill, are evident. In the pursuit of a hierarchical view of knowledge and skills, I find it helpful to compare Gagne, Briggs, and Wager (1992) and Bloom's (1956) ideas. To account for its diverse nature, learning is perceived by both theorists to assume two dimensions, the cognitive and affective dimensions.

Gagne *et al* 1992) describes the cognitive dimension as "intellectual skills", which he describes as " how" to do something of an intellectual sort, "cognitive strategies" are described by Gagne *et al* (1992) as "*internal process by which learners select and modify their ways of attending, learning, remembering, and thinking*" (Gagne *et al*, 1992: pp 66). Gagne *et al* (1992) describes verbal information, as knowing "that" or declarative knowledge (Gagne, 1992, pp: 46). According to Gagne *et al* (1992) motor skills and attitudes constitute the affective dimension. The cognitive dimension ranges from knowledge to evaluation, while the affective dimension includes receiving, responding attitudes and conceptualisation (Bloom *et al*, 1956).

The hierarchical view of knowledge and skills is inherent in the conceptualisation of learning as a complex phenomenon by both theorists. With Gagne, evidence of a hierarchy is captured within his intellectual skills (Gagne *et al*,1992, pp: 55) and his cognitive strategies (Gagne *et al.* 1992, pp: 68), while with Bloom *et al* (1956), the hierarchy of knowledge and skills is evident in both affective and cognitive dimensions (Bloom *et al.*1956, pp: 49-50). This is further supported by the following quote:

"The whole cognitive domain of taxonomy is arranged in a hierarchy, that is, each classification within it demands the skills and abilities which are lower in the classification order. The application category follows this rule in that to apply something requires comprehension of the method, theory, principle, or abstraction applied". (Bloom et al 1956).

Given the fact that this study is located within a hierarchical view of intellectual knowledge and skills, I find it necessary to explore Gagne's ideas in more detail. I find Gagne more useful in this study since Gagne's theory is explicit about hierarchy of knowledge and skills. Gagne is explicit about progression in learning.

Gagne claims that a learner has achieved a learning hierarchy when he or she acquires a set of capabilities from simpler to more complex in an orderly way (Gagne, 1970). A single capability to be learned represents what the learner is able to do when a hierarchy has been accomplished; this he terms performances. Super- ordinate capabilities will be more readily learned if the subordinate capabilities have been previously acquired, and are readily available for recall. For him then, a learning hierarchy identifies a set of intellectual skills that are ordered in a manner indicating a substantial amount of position transfer from skills of lower position to connected ones of higher position.

Gagne (1970) argues that a learning hierarchy does not suggest, "route learning", but it does provide evidence of the "present" or "missed" capability, or information that necessitates higher order learning. He argues that a learning hierarchy serves as a vehicle providing the basis for finding a suitable learning route for every student; for example, brighter students acquire both subordinate and super ordinate skills at once, while dull students cannot. Therefore, identification of these varied capabilities and establishment of their availability is important for effective teaching and learning.

Gagne's (1992) and Bloom's (1956) hierarchy of capabilities, as with all types of learning, is applicable in science learning as Gagne (1970) recognises that in developing intellectual skills in science, attention should first be given to concrete objects in order that learning is successful. The second level of learning is concept formation/learning followed by rule learning and finally, the ability to solve problems and apply acquired skills/capabilities to new situations. Gagne hierarchies knowledge and skills in the following way:

- Discriminating learning, for him, pertains to the ability to distinguish objects/events, for example, blue from green, high sounds from low sounds.
- Concept learning is exemplified by classification of objects or events accordingly to specified criteria, for example, "smooth" becomes not simply the feel of water-washed rocks, but a class applicable to a variety of objects, like silk, baby skin.
- Rule learning refers to learning of processes, such as observing, measuring, using space-time relation, inferring and manipulating variables.

- Problem solving refers to the establishment of basic and higher ordered rules and principles.

Therefore, rules perceived as relevant to specific science topics require prior learning of subordinate rules that are general to science, in that they deal with "processes" of obtaining scientific information. It is important to identify parallel views in both theorists, since both are relevant to scientific learning. Table 1 below shows the comparison.

TABLE 1: Hierarchy of knowledge and skills as conceived by Gagne (1970) and Bloom (1956) with Examples extracted from educators' assessment documents.

Gagne's Conceptualisation of Learning	**Bloom's conceptualisation of Learning**
Discrimination/concrete learning. e.g. The following chemical reaction takes place. 2Mg + $O_2 \rightarrow MgO$. Write down the symbols of: (a) Reactant (b) Product	Knowledge. e.g. Which two types of energy do our stars give off?
Concepts. e.g. The chemical formula of a blackboard chalk is $CaCo_3$. How many different elements are found in this compound?	Comprehension. e.g. what is meant by light year?
Rules. e.g. Why are rocks in the centre of earth molten?	Application. e.g. The greenhouse effect is very important for humans to survive. Discuss why it is so, and explain how the Greenhouse effect can become a problem on earth.
Problem-Solving e.g. if an object is travelling at 100 m/s in space, how far will	Application/Analysis/Synthesis. e.g. 'The sun will be around forever'. Do you agree with this

it travel in 20 seconds? Distance=speed x time=	statement? Substantiate your answer.

Gagne's "*discrimination*" is similar to Bloom's "*knowledge*" i.e. both recognise "making a distinction" between objects, events, rules, and classes, while Gagne's "*concepts*" are similar to Bloom's "*comprehension*" in that both call for demonstration and understanding of properties attributed to objects, events, terminologies, sequences and trends. Gagne's "*rules*" are similar to Bloom's "*application*", in that both call for demonstration of a learning process, i. e; rules are applicable in one or more instances, "*Problem solving*" of Gagne's hierarchy relates to "*application, analysis, and synthesis*" in Bloom's hierarchy.

It is important to note that "discrimination" and "knowledge" is included in all levels of the hierarchy of intellectual skills in both theorists. Therefore, Gagne's conception seems to parallel Bloom's conception of learning in general, and specifically to science learning, since both theorists hold similar perceptions as discussed above, i. e. cognitive learning, affective learning and that learning is hierarchical.

Table 1 above highlights the similarities between Bloom and Gagne's views of learning, since both approaches are relevant and applicable to science learning and assessment. Bloom's (1956) taxonomy has the potential to assist in determining the presence, absence, or missed capabilities or performances (assessment focused), while Gagne's (1970) statements seem to focus more on progression of learning.

For example, while evidence of discriminatory learning will be captured where assessment tasks emphasize knowledge of facts, events or relevant terminology, evidence of conceptual learning will be captured where assessment tasks emphasize comprehension. Likewise, rule learning will be evidenced by assessment items that emphasize application, while problem solving assessment tasks will place more emphasis on application, synthesis and analysis, i.e will be more evaluative. While this view suggests an integration of learning and assessment, it might expose how assessment practices are influenced by a hierarchical view of knowledge and skills.

2.2.2 Piaget's developmental stages in children learning: Basis for scientific curriculum design, especially in lower grades.

The notion of hierarchy and its applicability in science learning is not limited to the above theorists. This conception is common in other learning theorists like Piaget. Piaget (1964) conceptualises learning as operating within the cognitive domain. To account for a hierarchical view, Piaget (1964) views children's thinking as ranging from pre-operational thinking through concrete operational (Gagne's discrimination) thinking to formal operational thinking (Bennett, 2003:pp 54) (Gagne's concepts, rules and problem-solving).

Piaget (1964) explicitly associates learning with children's developmental stages. Bennett (2003) argues that Piaget's theory assumes that the child has attained concrete operational thinking if he/she displays the ability to conserve, while at the same time the child grasps concepts and becomes able to classify objects systematically (Bennett 2003: 54). In Gagne's terminology this will be referred to as discrimination and concept learning since the ability to conserve will suggest recognition of the fact that change in form or arrangement does not necessarily mean change in quantity. Children's thinking in the concrete operational stage is based on their experiences of real life objects and events (Bennett 2003). Formal operational thinking is characterised by the ability to deal with abstract ideas, and in this stage, children will be in a position to set and test hypotheses (Bennett, 2003). Piaget's formal operational thinking relates well to Gagne's (1970) and Bloom's (1956) rules and problem- solving in that all three theorists propose that the child will be engaged with problem solving thinking activities which indeed call for abstraction. Piaget's (1964) theory concerns the general nature of development of cognitive/intellectual skills, but is relevant in teaching and learning science. The notion of hierarchy is implicit in his conception of learning.

Piaget describes the way in which children's thinking develops, which forms the basis of the development of science curricula. His learning theory is based on the concepts of assimilation and accommodation (Bennett, 2003). Although Piaget is not necessarily a learning theorist, his stages of children's development may therefore translate into Gagne and Bloom's hierarchy.

2.3 SCIENTIFICALLY WORTHWHILE KNOWLEDGE AND SKILLS: "SCIENTIFIC LEARNING"

Scientifically worthwhile knowledge is perceived by Fisher (1990) to be achieved if one is operating or engaged in conceptual learning. He argues that:

"C*onceptualisation is described as a process of representing, observing, inferring, recording, measuring, in a way that makes clear patterns and organisations*" (pp 133).

It is clear that Fisher (1990) describes scientifically worthwhile knowledge and skills as the one that recognises "processes" as opposed to a "*cognitive dimension*" like thinking skills, analysing, application, synthesis, recall, comprehension.

Jones, Simons, Black, Fairbrother, and Watson, *(*1992) describe concepts as packages of meaning that capture regularities, patterns, relationships among objects and events, and other concepts. According to Jones *et al* (1992) concepts vary along a continuum from simple labels of concrete entities to higher-level abstract representations that describe complex relationships among many subordinate concepts. Therefore, inherent in this is the notion of a hierarchical organisation of knowledge and skills. This seems to agree with Gagne's (1970) conception of learning and how scientific learning should operate.

For scientists meaningful conceptual understanding in science goes beyond knowing facts and labels, but conceptual understanding can be used to explain or explore new situations (inquiry learning). Therefore, reaching a higher level of conceptual abstraction is central to scientific learning. Fisher (1990) and Jones *et al* (1992)'s argument suggest that scientists emphasize "processes" defined as scientific processes. But "content" is also critical, i.e. conceptualisation of the disciplines, which means conceptual organisation rather than a series of discrete topics. But while the emphasis on "processes" and "content" is crucial, "processes" are preferred to "content"', as Hodson (1993) asserts that learning science is through scientific inquiry. This suggests that learning science involves the application of skills like observation, classification, measuring, hypothesising. Hodson (1993) cited in Bennett (2003) considers these skills as cognitive and general across all areas of study. The emphasis on "processes" is further supported by some curriculum projects like Warwick Process Science where Screen (1986) argues that:

"The emphasis on processes extends beyond practical work, with the principal aim being to teach pupils about processes, rather than content of science .The most valuable aspects of a scientific education are those that remain after the facts have been forgotten" (pp 89)

The notion of "scientific inquiry" is further supported by Mosothwane's (1995) study when he states: *"teaching science is by means of investigation which will enhance and promote children's understanding"(pp 79).*

It is worth noting that process science has been the subjects of heated debate and criticism by science educators such as Millar (1989) and Driver (1987), nevertheless science educators have shifted towards engaging pupils in an investigation where progression is addressed through increasing levels of sophistication in terms of the associated procedural and conceptual understanding (Wellington: 1989) which were defined in chapter one.

For scientists, rote learning (recalling unrelated information) is not worthwhile in learning science, but relating concepts and using concepts for better understanding is true scientific learning. This suggests that conceptual coherence is a significant phenomenon in science learning.

2.4 VIEWS OF SCIENTIFIC KNOWLEDGE AS THE BASIS FOR SCIENTIFIC ASSESSMENT PRACTICES.

Eylon, Ben-Zui, and Silberstein, (1987) state that:

"If an educator attempts to capture a reliable picture of student's thinking, it is crucial to study behaviours or several tasks where the relationship between tasks is well defined. For example, the relationship can be a hierarchical one where one task is a component of another, more complex task. By studying systematically patterns of behaviour on related tasks one can illuminate the sources of difficulty that the students have." (pp: 188).

This argument implies that analysis of task performances are done in a hierarchical way and includes the notion of consistency and progression in performances. Eylon *et al* (1987) therefore believe that assessment practices are influenced by a hierarchical view of learning in science, as they further state that:

"In order to decide what is the reason for an observed difficulty in a given complex task, it is thus necessary also to examine the student's behaviour on simpler component tasks, and to study the relationship between the components and the complex tasks, likewise, in judging a student's performance as correct in tackling complex tasks one can learn about the strength of concepts and procedures involved in the original tasks"(pp: 189).

The above argument suggests that certain capabilities precede other ones, and assessment practices should recognise this progression of knowledge. Therefore, one can claim that by studying a hierarchical spectrum of tasks (a hierarchy of learning) an educator measures the nature of achievement (assessment being influenced by a hierarchical view of learning). Thus, it is necessary to explore an educator's perception of a hierarchy of knowledge and skills, and the extent to which their perceptions influence their assessment practices.

While most scientists seem to agree on what constitutes scientifically worthwhile knowledge i. e. conceptual as well as procedural knowledge, which suggests learning "content" as well as "processes" (Hodson 1993), the symbolic relationship existing between the two is strongly recognised. Hodson (1993) defines symbolic relationship in the following way:

"Because of the dynamic interactive relationships among observation, experiment and theoretical knowledge, this involvement in inquiry helps students to refine their conceptual knowledge and develop their procedural skills concurrently". (pp:141).

(Hodson (1993) asserts that through engagement in scientific activity (classifying, observing etc), conceptual knowledge is modified, rearranged and manipulated, i.e. conceptual development is structured and assisted by scientific inquiry or activity. Implicit in this argument is the operation of cognitive strategies. Based on this view, therefore assessment activities must recognise both conceptual knowledge and procedural knowledge. For example, Hodson (1993) states:

"*Doing science is more than performing a collection of individual task.*" (pp: 129).

This statement rules out much focus on skill-based testing (assessment being driven by outcomes) in science.

Hodson (1993) warns that in adopting a "skill-based approach" in executing assessment practices in science, there is a danger that what is measurable is being taught, which therefore decontexualises scientific learning. Decontexualisation, Hodson (1993) argues is apparent if the focus is centralised around outcomes, neglecting conceptual coherence and procedural knowledge.

Outcomes driven assessment has a place in science. But while this is true, assessment activities in science on the other hand should align with curriculum expectations i. e. recognition of the "*symbolic relationship*" between "*conceptual knowledge*" and "*procedural knowledge*" must be made, if assessment is to be educative. "Educative", in this sense means to enhance and promote learning by engaging learners with interesting and challenging experiences aimed at developing further insights and understanding.

Hodson (1993) believes that assessment practices in science should be constructive, in the sense that assessment needs to have the potential to map student's actual knowledge. This means the educator must create opportunities for students to talk about what they perceive knowing or are unsure of. Such a view seems to recast assessment practices in science as operating within an informal contract of shared responsibilities in learning (Hodson: 1993: 132).

It is true that science is perceived as a holistic enquiry (i.e. it embodies both conceptual knowledge and procedural knowledge), not simply a matter of following rules that require particular behaviours as portrayed by skills-based testing in Hodson's language, outcomes based driven in the South African context. Assessment practices will have to be holistic as well if assessment is meant to promote learning. Such a view suggests assessment as being educative. Hodson's (1993) view of holistic assessment in science draws on Bloom's (1956) taxonomy, and seems to support a hierarchical view of knowledge and skills in the following statement:

"Holistic assessment involves asking questions like: Has a body of scientific knowledge been used appropriately and a good range of ideas been generated (synthesis in Bloom's terminology), has the student sensibly and imaginatively evaluated a range of alternative ideas (analysis in Bloom's terminology), have data been sensibly interpreted? Is the final conclusion reasonable and appropriated (evaluation in Bloom's terminology)?"(pp 143).

Sand and Bishop (1984) cited in Christofi (1988) further support a hierarchical taxonomy of the objectives of assessing skills in laboratory work. The hierarchical taxonomy of objectives of practical work they suggest ranges from: *"knowledge of apparatus, of procedures, knowledge of ways of using apparatus, the ability to use apparatus, implement procedures, select appropriate procedures for a particular problem, observe the material under investigation, ability to observe changes/differences taking place in the material under investigation", (pp 31-32)*

Levinson (1994, pp 125) argues that:

"Assessment is liable to be more successful if pupils understand what is expected of them, both in terms of what they have to know or are able to do, and of the performances that are needed to demonstrate their achievements"

Following Hodson's (1993) holistic view of assessment and Levinson's (1994) argument about assessment, it stands to reason that assessment practices will be successful if they consider procedural and conceptual knowledge, and that students are aware of and understand procedural and conceptual performances that are expected of them, and the progression of these performances. Fairbrother (1988) cited in Wellington (1989) further supports the educative value of assessment practices, and the recognition of hierarchy in science assessment practices when he states that:

"The absence of a hierarchy of progression implies a lack of teaching strategy designed to give a development of skills and removes one of the planks of formative assessment", (pp 105).

Wellington (1991) further argues that a child's developmental models of learning and assessment methods should be brought together as he advocates that 'developmentalism seems to be riding high and tends to govern the models of teacher assessment of practical work in the GCSE', (pp 105).

Fairbrother (1988) suggests that assessment practices should be undertaken in context. Assessment tasks should focus on generalised skills while at the same time consideration of specific skills is made. Generalised skills, according to Fairbrother (1988) are setting objectives, recognising obstacles, interpretation, and course of action, decision-making, implementation, evaluation and review. Fairbrother (1988) considers these skills as applicable in science and transferable to other situations as well. Specific skills, according to him, are skills that are clearly defined and have clear criteria like, observation, measuring, recording, inferring, application, reading, using a metre ruler, lighting a bunsen burner, using a hand lens, drawing graphs, formulating hypotheses. Fairbrother (1988) considers specific skill as relevant to science.

If we teach generalised and specific skills in science, the educator's assessment practices will have to be sensitive to generalised and specific skill. Fairbrother (1988) considers this approach to be holistic. His conception of science learning and assessment practices seems to agree with Hodson's (1993) conception of a holistic approach in teaching and assessment practices, and of other science educators as discussed in Christofi (1988). Fairbrother's (1988) conceptualisation of science teaching, learning and assessment seems to recast assessment practices as having educational value.

2.5 NEW POLICIES ON ASSESSMENT IN SOUTH AFRICAN CONTEXT.

The shift from a psychometric mode of assessment towards educational assessment is no exception with the South African context; the same is evident in countries like New Zealand. Educational assessment integrates teaching and learning, hence the conceptualisation of classroom assessment under Curriculum 2005 in South Africa is guided by this notion of "integration, and "criterion referencing" i.e. assessing a learner against his or her level of development as opposed to other learners. This notion of integration is supported by Gipps (1994) as he claims that integrated assessment is an attempt to shift towards a broader model of educational assessment (where assessment should not be seen as add-on that is separate from teaching and learning, as does the psychometric approach).

The above argument broadens the idea proposed by Hodson (1993), in favour of holistic assessment. Assessment tasks must be sensitive towards scientific learning as a holistic inquiry. While one cannot entirely divorce teaching from learning, it must be noted, however that the present study focuses on learning and assessment.

The Revised National Curriculum Statement for Natural Sciences Grades R-9 (2002:4) in South African portrays a scientific inquiry kind of learning in science, as it states that:

"To be accepted as science, certain methods of inquiry are generally used. These methods include formation of hypotheses, repeated investigations are undertaken resulting methods and results are carefully examined and debated"

The Revised National Curriculum Statement for Natural Sciences (2002) emphasizes process skills and this is more evident in learning outcome one i.e. scientific investigation than learning outcome two and three i. e. constructing science knowledge and science, society and the Environment. The learners in the learning outcome one are expected to plan investigations, conduct investigations and collect data, and to evaluate and to communicate data. It is important to note that the expected skills in learning outcome two and three are more cognitive than being process skills. These skills are recalling meaningful information, categorising information, interpreting information, predicting, hypothising, and understanding science and the impact of science. It is evident that these "cognitive skills" are underpinned by the notion of hierarchy even though the notion of hierarchy is not explicitly expelled out.

The emphasis on process skills in South African Context seems to be in line with what other scientists advocate as argued above. If Curriculum 2005 is driven by the notion of integration of teaching, learning and assessment, and teaching and learning is underpinned by the notion of hierarchy, assessment practices in South African context must demonstrate a hierarchical view of knowledge and skills.

Learning outcomes are clearly organised around the notion of hierarchy. For example, learning outcome one (LO1) which is scientific investigation (concrete learning) is the only learning outcome that applies to Grade R and continues through to Grade nine, while learning outcomes two (LO2) and three (LO3) which is constructing scientific knowledge (concepts and rules) are introduced in Grade four and expected performances increase in complexity with Grade. For example, "recalling meaningful information and categorising information" is expected from Grades four and five, while "interpretation information" is introduced in grade six and "applying of knowledge to unfamiliar problems" is introduced in Grade seven. Learning outcome three (LO3) which is Science, Society and the Environment is introduced in Grade four and continues through to Grade nine. (Revised National Curriculum Statement, Natural Science Grade R-9 (pp: 16-20).

Performances to be assessed range from simple to complex across all grades (the notion of hierarchy is evident). For example, in the construction of knowledge as learning outcome two (conceptual knowledge), expected performances range from recalling meaningful information to application of knowledge, while the expectation of each performance increases with each level, i. e. recall and categorisation of information are expected in Grade four and five, respectively, while applicatio*n* is expected in Grade six, interpretation and application is expected in Grades seven-nine (Revised National Curriculum Statement Grades R-9 Natural Sciences, 2002: pp: 18-19).

Likewise, in scientific investigation as learning outcome one (procedural knowledge), expected performances range from application to evaluation. Within each performance, *skills increase with each level*. For example, in evaluating data, the learner is expected to "*think*" in Grade-R, "*report results*" in Grade-one, "*explain the results*" in Grade-two, "*reflect on explanation*" in Grade-three, and make "*suggestions for improvements*" in Grade-four. (Revised National curriculum Statement Grades R-9 Natural Sciences, 2002: 16-17).

Educators therefore need to be knowledgeable about the theory of a hierarchy of knowledge and skills, that underpins the Revised National Curriculum Statement for Natural Sciences and this will enable them to assess holistically in their assessment practices.

2.6 CONCLUSIONS: SOME GAPS IN THE LITERATURE.

While strong evidence has been cited from the literature that scientific learning occur mainly through investigation, and this assertion is further supported by Jenkins's study (2000) where a concern is expressed that *"investigative science has been squeezed out"(pp:*334*)* little evidence exists as to the extent to which educators' perceptions influence the design of assessment tasks, if a holistic assessment mode is to be adopted.

If the notion holistic assessment is to be sustained within the South African context, it is critical to explore the basis on which Natural Science educators judge student performances and their perceptions of scientific knowledge. Literature on this topic is scarce. While Roberta's (1991) research cited in Treagust, Jacobowitz, Gallagher, and Parker, (1999) reflect an educator's strong belief on a hierarchical view of scientific knowledge and skills in doing his or her learning activities, his or her assessment activities do not reflect that assessment activities have been developed on the basis of a hierarchy of knowledge and skills. Assessment tasks remain as mere activities. It is necessary to explore the extent to which such a perception becomes influential in designing assessment tasks.

The literature contains reference to what constitutes the basis for judging student achievements, as Eylon *et al* (1987:188-189) states that*: " in gaining insights into sources of student difficulties in handling complex tasks, one has to consider how simpler tasks have been executed*". A hierarchical view of knowledge operates in designing assessment tasks, but little evidence is available on to what extent educators use a hierarchical view of knowledge and skills in judging student achievements in science.

CHAPTER THREE: METHODOLOGY

3.1 NTRODUCTION

This chapter outlines the theoretical and the methodological choices adopted in conducting this study. The theoretical framework discussed in this chapter highlights the methodological framework on which the research design, data collection and analyses are based. This discussion will be followed by an outline description of practicalities of designing the study, collecting and analysing data. I hope to highlight the links between what was intended, and what emanated in practice. It is essential to highlight the above point, since it is possible that the investigation assumed different dimensions from what was intended.

3.2 THEORETICAL FRAMEWORK

In chapter two I argued that this study should be understood from Gagne's (1970) conceptualisation of learning as a complex phenomenon. This study draws on the cumulative nature of complex learning, which suggests a hierarchical view of knowledge and skills. In chapter one I have argued that if conceptual coherence, sequencing and progression are recognised as crucial factors in teaching and learning Science, a hierarchical view of learning should be recognised. Further if a hierarchy of learning is important in natural Sciences, assessment practices must reflect a hierarchical view of knowledge and skills if they are to form an integral part of teaching and learning. This view is supported by Eylon *et al* (1989:200) as he states that:

"If an educator attempts to capture a reliable picture of students' thinking, it is crucial to study behaviours or several tasks where the relationship between tasks is well defined. For example, the relationship can be a hierarchical one where the task is a component of another, more complex task"

It is on the basis of the above argument that this study draws on Gagne's theory of learning as a complex phenomenon (Gagne 1985). In this section I briefly describe Gagne's key propositions of learning as a complex phenomenon. This attempt is directed towards locating the study as such. I also give principles of interpretativism, as another theoretical framework adopted in this study.

3. 2.1 GAGNES' PROPOSITIONS.

Gagne (1985) holds that learning is a complex phenomenon. To account for complexity of learning, Gagne makes the following prepositions.

- Learning is diverse. In this proposition he asserts that learning is composed of different capabilities.
- Learning is cumulative. In this proposition he assumes that it is the combination of these different capabilities that enables learners to execute complex tasks.
- Learning ranges from simple to complex tasks.

It is important to note that this study should be understood within the logic of second and the third propositions. The reason is that both propositions are based on the notion of a hierarchical order of knowledge and intellectual skills.

3.2.2 INTERPRETATIVISM AS A THEORETICAL FRAMEWORK.

Interpretativism becomes a theoretical framework when one has to interpret one's perspective. Since this study explores educator's perceptions of learning i.e. interpreting pre-interpreted information, interpretativism is a relevant theoretical framework to gain an understanding of educators' assessment practices.

Hitchcock and Hughes (1989:28-29) argue that:

- Interpretative researchers stress the principles of intentionality to grasp the active side of human behaviour.

- Interpretative researchers stress that human action is for the most part deliberate and that people do not simply react to events and situations, but reflect on situations.

♦ Human beings make choices and are able to act upon the world and change in line with their own needs, aspirations or perceptions. It is in the context of this assertion that this study investigates the extent to which educators' perceptions influence their assessment practices.

♦ Interpretative researchers therefore take seriously the question of language and meaning, and give priority to first unravelling an actor's descriptions of events and activities in a qualitative fashion rather than focusing upon observer's descriptions in a quantitative fashion.

♦ Interpretative research is open-ended, prepared to change direction and accept the possibility of using a variety of sources of data, since the social world is complex. It is within the context of this assertion that the researcher has adopted a variety of sources of data, such as observation, document analyses and interviews.

♦ Interpretative models of social research are geared towards reconstructing the actor's perspectives. In reconstructing the actor's perspectives, one is engaged with meaning making. If reconstruction aims to make meaning, interpretativism is an appropriate theoretical framework for this study.

3.3 METHODOLOGY

Hitchcock and Hughes (1995:20) contend that methodology is a theory or an analysis of how research should operate. The choice of method is determined by the chosen topic and the kind of data to be collected. Cohen *et al* (2000:45) agree that the aim of methodology is to help us to understand in the broadest possible terms, the process rather than the products of scientific inquiry. Cohen *et al* (2000) further state that the choice of the method is determined by the nature of the topic chosen and the kind of data to be collected.

The literature reminds us that the theoretical framework informing the study determines the research approach and methods to be adopted (Cohen *et al* 2000). The real issue is the "fitness for the purpose". This will mean using research methods and approaches that are relevant to the topic under research.

Since this study is interested in meanings the educators give to their assessment practices, a qualitative methodology in this study is appropriate. The exploratory nature of this qualitative project is supported by Filler and Pollard (2000:40), where they conceptualise educators' assessment practices as products of negotiated classroom events and as related to their specific context. Therefore the question of "meaning" and "interpretation" is crucial; hence a qualitative interpretative method is adopted.

While the qualitative approach is the dominant methodology, a quantitative observation schedule based on a checklist and document analysis was used in this study.

3.3.1 THE CHOICE OF QUALITATIVE APPROACH.

A case study approach is adopted in this study. The attempt is to gain a deep understanding of individual educator's assessment perceptions and practices, and to treat individual cases as unique so as to understand assessment perceptions and practices. The kind of critical questions that the project wishes to answer can be best understood through case study. Yin (1994) asserts that case studies can best answer the "*why" and "how*" type of questions.

The "why" question, in this study attempts to investigate science educators' assessment strategies (what perception do educators hold in relation to learning and assessment?). It is therefore towards addressing the "why" question that this study will ultimately gather educator's *perceptions*.

It is important to note that, while quantitative methods have the potential to survey large numbers of Science educators, the extent to which quantitative methods can capture thick data on educators' practices becomes questionable. The act of "*practice*" carries with it the way educators assess in their context, in their natural settings. Therefore the researcher needed to grasp the meanings in practice. Put differently, the researcher has to interpret what constitute educators' perceptions of learning and assessment practices. In this study I construct the self-understanding of educators, as being engaged in their particular actions. Denzin and Lincon (1989) assert that it is possible to understand the subjective meaning of actions (grasping the actor's beliefs and desires), yet do so in an objective manner. In order not to misinterpret the original meanings, I had to assume the position of a disinterested observer.

The choice of a qualitative case study is a deliberate attempt to give sufficient meaning to educator's interpretations. It has to be kept in mind that while the critical questions attempt to address the "why" question, they form a component of the bigger question which can be rephrased as *"How do Grade 8 Natural Science educators structure classroom assessments?"*(answered from observations and document analysis), "*Why do educators make choices that they make*?" (answered from interviews).

3.4 UNDERTAKING RESEARCH.

Cresswell (1994:147) asserts that qualitative research is interpretive research; as such biases, values, and judgements of research become explicitly stated. These, he asserts include familiarity with the topic, the setting and the informants. Such experiences are likely to shape the interpretation of the report.

Following the above arguments, I have been a Life Science educator in Secondary School in KwaZulu-Natal for the past thirteen years. My involvement in Science subjects sensitised me to pursue Science educators' assessment practices. Assessment practices as portrayed in Curriculum 2005 should be integrated with learning and teaching. Curriculum 2005 recognises that assessment practices should concentrate on the process of learning rather than the product. Therefore, the way learning is conceptualised by Science educators becomes crucial. In fields like Natural Sciences, conceptual coherence, a hierarchical order of knowledge and skills is critical. Assessment practices must reflect a hierarchy of knowledge and conceptual coherence.

3.4.1 RESEARCH DESIGN

Creswell (1994) outlines models of research design. These are pronounced as, two-phase design, "dominant-less dominant design" and "mixed methodology design". This project adopts the "dominant-less dominant design". Creswell (1994) defines this design as when the researcher presents the study within a single dominant paradigm, with one small component of the overall study drawn from alternative paradigm. This project adopted a qualitative approach, and utilised quantitative methods to a lesser extent.

In qualitative studies, the act of combining methods and design is realised by means of "triangulation". Denzin and Lincoln (1978) use this term based on the assumption that any bias inherent in particular data, source, investigator and method would be neutralised when used in conjunction with other data sources, investigator, and method. For example, Cohen *et al* (1994:233) contend that:

"Triangulation in social science attempts to explain more fully the richness and complexity of human behaviour by studying it from more than one standpoint, often by making use of qualitative and quantitative data"

An advantage of the multi- method approach, Cohen *et al* (2000) argue, is:

"Exclusive reliance on one method may distort or bias the researcher's picture of a particular slice of reality she/he is investigating. The more methods contrast with other, the greater the researcher's confidence in findings confirmed by such different methods".

Based on the above argument, the adoption of document analysis, classroom observation and interviews ensured a range of data from different sources, and hence, my confidence in my findings.

3. 4.2.CHOICE Of SAMPLE.

While Patton (1987), Gold (1997), and Brown and Dawling (1998) prefer to use the term sampling, to describe the choice of cases to study, Yin (1994) prefers to use the term replication (Lubisi, 2000). Yin (1994) describes the logic of replication in the following way:

"*Each case must be carefully selected so that it either (a) predicts similar results (*a *literal replication*) or (b) *produces contrasting results but for predictable reasons (a theoretical replication)"*. When the term sampling is used in this study, it will be used with Lubisi and Yin's replication logic in mind.

Patton (1987) describes sampling extensively arguing that sampling for qualitative evaluation requires the selection of information rich cases. Thus in the present study four different schools, providing four educators as units of analyses were sampled to yield information rich cases. This study has followed Yin (1994) and Lubisi's (2000) logic of replication in order to achieve a thick description of information.

3.4.3 SELECTION OF SCHOOLS.

Schools were selected based on their functionality. Functional schools had to be characterised by the following features:

- A focus on learning and teaching to be a central activity of school.
- A culture of concern and a sense of responsibility within the school.
- A school able to achieve good results regardless of adverse conditions within the community.

The selection of schools was influenced by my familiarity with the good reputation of schools for the past thirteen years. My original choice of schools had to change due to difficulties in gaining access to schools, and to educators. Of the four identified none became the research site. I ended up with one DET school at Imbali that did not necessarily meet all the criteria. My familiarity in the school, and also to the participant facilitated easy access. This school is about ten kilometres away from my school and the participant once taught Biology in my school. Three more schools were selected from previously advantaged schools within the Pietermaritzburg district. These schools presented strong characteristics of functionality.

It has to be noted that the modification of the research sites bears no significant adverse impact on the validity and reliability of data, given the fact that the unit of analysis remains the educator, not the school. A combination of schools provides the potential for providing information rich cases and to trace replication that might exist, in order to reach a thick description of data.

Educators that were selected, as participants were all Grade eight Natural Science educators. Educators were selected based on the fact that they had one year's experience of teaching Grade eight Natural Sciences.

Effectiveness of an educator, gender, race, nationality, age, qualification was considered less important. In the interest of ethical consideration, anonymity, and rapport promised to the "informants", the names of schools and of the educators are not mentioned.

3.4.4 GAINING ACCESS:

Hornsby-Smith (1993) reminds us of the need to differentiate between physical access and social access. The process of gaining access, Hornsby-Smith (993:54) argues:

"Involves continuous renegotiation, bargaining, and establishing trustful relations with gatekeepers, and those being studied".

Brogdan and Biklen (1992) raise the need to know something about hierarchy and rules of a particular school, the need to develop rapport with participants and the need for a researcher to explain his/her intentions in the field. In order to gain access to various schools, and to the "informants" I had to negotiate access through levels of bureaucracy. I gave detailed explanation of my intentions, to the principal, to the Head of Department, and to the participant informant (in the township school). Access to suburban school was facilitated by my supervisor's familiarity with the schools and well-established relationships with participants. But again, such process had to follow lines of bureaucracy.

3.5. METHODS OF COLLECTING DATA

This study uses methodological triangulation using data gathered from classroom observations, document analysis, and interviews with the educators. Each method is described below. Cohen *et al* (1994) support this approach as they argue that the more methods contrast with one another, the greater the researcher's confidence in findings confirmed by such methods.

3.5.1 OBSERVATIONS.

Classroom assessment events were observed with the aim of understanding the explanation the educator gives for his/her assessment practices. Since the focus of the study is on assessment practices in the classroom settings, observations were focused on how assessment tasks are designed and what is being assessed. I was interested in the perception the educators hold in relation to a hierarchy of knowledge and skills, and to what extent educator's assessment tasks are based on this view. In the light of the above assumption, a structured observation schedule was used. Categories were worked out in advance in order to facilitate the capturing of necessary data. The observation schedule was developed from Gagne's (1985) summary of intellectual skills and knowledge, from simple to complex (Appendix A). A description of each skill serves as an indicator of each skill in an educator's assessment tasks.

The researcher was aware of the limitations that might be inherent in this instrument. For example, there was a possibility of considering observed events as providing evidence of underlying thinking and perception that might lead to misinterpretation of information and data. Cohen *et al* (2000) argue that there is an assumption that observed behaviour provides evidence of underlying feelings. I countered the problem of misinterpretation by using interviews and document analysis instruments.

Creswell (1994:150) argues that while "private" information may be observed that the researcher cannot report, the researcher can record information as it occurs; explore topics that the informant may be uncomfortable with. While the researcher may not have good attending and observing skills nevertheless unusual aspects can be noticed during observation (Creswell 1994). Structured observation was necessary to focus my observation.

I used a structured observation schedule to capture information in a live situation that the participant informant may have been uncomfortable with. It is also within this context that I hoped to capture critical incidents that might be regarded as private information by the informants to come to the true perspective of educator's perceptions of assessment practices in science. I wanted also to observe educators' assessment practices in the informal classroom situation; therefore I found it necessary to use classroom observations.

3.5.2 THE OBSERVATION SCHEDULE AS A RESEARCH TOOL.

A maximum of three lessons were observed per educator, totalling twelve observed lessons. Cohen et al (2000: 36) argue that:

"If we know in advanced what we wish to observe, i.e. if the observer is concerned to chart the incidence, presence and frequency of elements, may be wishes to compare one situation with another, then it is more efficient in terms of time to go into a situation with an already designed observation schedule"

It was in this light that a structured observation schedule was used during observations. The observation schedule was developed from Gagne's summary of intellectual skills and knowledge, ranging from simple to complex. A description of each skill served as an indicator of each skill. A tick used in the schedule served as evidence of each skill.

In capturing necessary data using a structured observation schedule I had to be guided by terms/phrases that were indicating a particular skill/knowledge being assessed. Phrases like "*mention*", "*write down*", "*which types*", "*identifies*" indicated discrimination learning, while phrases like "*how*", "*what is meant*", "*show by an angular diagram*" indicated concept leaning. The "*why*", "*explain*", "*describe*", "*demonstrate*", "*what was the night time temperature*?" phrases indicated rule learning, while phrase like "*substantiate*", "*give evidence*", "*calculate the distance based on given data*" (descriptive phrases) indicated problem solving learning.

Every assessment opportunity was analysed during each observation using a rating of "evident" and not evident". The category rated "not evident" does not mean deficiency of skill, or rather that the educator is less knowledgeable in that skill. It simply means that this category might not have been important to the educator to integrate in his/her teaching at that time. Again, it has to be noted that I was interested in assessment practices as having an educational value. The assessment practices had to facilitate science learning during the lesson. In chapter two I have outlined the ideas of Hodson (1993), who argues that assessment practices must be educative with a view to promote learning, by engaging learners with interesting and challenging experiences, aimed at developing further insights and understanding.

I was aware of the limitations of the schedule. For example, Cohen *et al* (2000) argue that while structured observations have the potential to provide useful data, they tend to be behaviourist, and the individual's subjectivity might be lost to an aggregated score. There is a further danger that observed behaviour might be considered as providing evidence of underlying perceptions Cohen *et al* (2000), thus, the use of scores per se was not perceived to be vital. The checklist scale provided the focus of the research, and facilitated capturing relevant data.

3.5.3. DOCUMENT ANALYSIS.

The purpose of analysing assessment documents was to seek evidence of application of a hierarchy of learning. Each educator's assessment tasks were collected to capture what the educator values and applies in practice. Analysis of educator's assessment documents had the potential to verify the findings from observations of classroom assessment practices. Eisner (1991) contends that documents and artefacts provides a kind of operational definition of what teachers value, and help the researcher to understand the context within which teachers do their work.

Creswell (1994) argues that documents may be regarded as protected or private information unavailable to the public, and therefore inaccessible. The rapport and trust established in gaining social access to the informants overcame this limitation. I had no difficulty in accessing the educators' assessment documents, such as written projects, assignments, class and controlled tests, class exercises and essays that may have indeed been regarded as private.

Creswell (1994) argues that document analysis enables the researcher to obtain the language and words of informants. As written evidence, documents saved a researcher the time and expense of transcribing. As written evidence, it was possible for me to capture educators' beliefs and values, and there was no need for transcribing. A wide range of assessment documents provided rich information, and thick description of educators' classroom assessment practices.

3.5.4. DOCUMENT ANALYSIS INSTRUMENT AS A RESEARCH TOOL.

Cohen *et al* (2000) argue that observed behaviour is in fact "inferred". It was on this basis that a wide range of educator's assessment documents were analysed in detail, in order to support inferences about educators' assessment practices that were made during observations. The document analysis instrument was again developed from Gagne's summary of intellectual skills and knowledge that indicate a hierarchy of skills. This hierarchy ranges from concrete to problem-solving skills. The assessment documents that were analysed were worksheets, essays, projects, and assignments, class exercises/activities and controlled tests over six months. A decision had to be made whether to use whole year assessment tasks, or only those used in the first and second term. The latter option was envisaged as sufficient to provide information rich description.

The *"mention", "name", "which"* questions indicated discrimination learning skill, while the *"how", "what is meant by"* indicated the concept learning skill. The "*why*", "*describe*", "*explain*", "*discuss*" questions indicated rule learning skills, while "*substantiate*", "*provide supporting evidence*" indicated problem-solving skill.

3.5.5. INTERVIEWS

Eisner (1991) advises against the use of formal inflexibly structured interviews. He writes: *"Conducting a good interview is in some ways like participating in a good conversation, listening intentionally and asking questions that focus on concrete examples and feelings rather than on abstract speculations, which are less likely to provide genuinely meaningful information (pp119)"*

It is in this light that more open-ended questions were perceived to be most appropriate for the interviews. It was envisaged that this kind of interview would capture a detailed comprehensive picture of subjective meanings of educators' assessment practices and in-depth information (why things were done in a particular way). Cohen et al (2000) argues that interviews may validate other methods, or go deeper into the motivation of respondents. In adopting open-ended questions, I hoped to elicit useful insights into perceptions that informed educators' assessment practices, particularly in relation to a hierarchy of knowledge and skills. Goodson (1992) contends that it is imperative to listen to teachers' voices because they carry the exact tone and feeling that are conveyed by the way the educator speaks.

Eisner (1991) recommends that the interview should focus attention on things the interviewees have done. It is often useful for the researcher to ask teachers to explain something they said in class. It is in this light that I have adopted open-ended questions.

I am quite aware of the limitations inherent in using this data collection instrument. For example, its interactive nature allows "adaptability" (Borg and Gall: 1979), while on the other hand it can lead to subjectivity and possible bias. Such subjectivity and biases were overcome by developing a semi-structured interview schedule, which then focused the conversation. Mother tongue language for the entire respondents was not the same. While it was obvious that one respondent spoke Afrikaans, the other two educators spoke English and the remaining one was Zulu-speaking and the interviewer's mother tongue was Zulu.

3.5.6. INTERVIEW SCHEDULE AS A RESEARCH TOOL.

Regardless of the diverse languages presented by the respondents, the interview was conducted in English. I experienced problems with the diverse languages. There was misinterpretation of questions and answers. It was difficult to elicit hidden meanings because of lack of understanding of certain concepts that were used by the interviewer. I had to rephrase the questions in order to clarify certain questions that were asked or to get clarity on what the respondents said.

A tape-recorder and audio- tapes were used to record the interviews, which were later transcribed. There are certain disadvantages to using a tape-recorder, for example, the respondents may be reluctant to give personal information when they know that their responses are being recorded. I overcame this obstacle by first explaining the purpose of interviewing and recording, so as to gain the confidence of the respondents. Carlgren, Handel and Vaage (1994) argue for the establishment of mutual trust between the researcher and the respondents. On the other hand using a tape-recorder reduces the tendency for the interviewer to make an unconscious selection of data that favour his/her own biases.

An interview schedule was designed to capture each educator's beliefs and perceptions about science learning and their assessment practices, in relation to a hierarchy of knowledge and skills. The questions in the interview guide were not divided into sections, but careful thought was given to include question that would elicit necessary data. Questions were included that captured educators' biographies, educators' beliefs about science learning in relation to a hierarchy of knowledge and skills, organisation of their assessment tasks in order of importance. The researcher originally designed the questions used in this study.

3.6. ANALYSIS OF DATA FROM OBSERVATION SCHEDULES AND ASSESSMENT DOCUMENTS.

Since the study adopted a dominant-less dominant approach, data from observation schedules and from assessment documents were quantified. The total number of question items that emphasised each category of hierarchy had to be quantified in both instances to understand the educators' perceptions and assessment strategies. The raw marks of skills per assessment task had to be converted into a percentage, in order to make valid comparisons. Controlled and class tests were combined as this constituted the formal kind of assessment. Worksheets/Class activities/Class Exercises were combined as this also constituted informal kind of assessment. Likewise, projects and assignments were added together as they are long written, formal or informal activities. Adding the total number of question items asked per skill, and converting this mark into a percentage arrived at the weighting of each skill.

3.7. ANALYSIS OF THE TRANSCRIBED DATA FROM INTERVIEW SCHEDULE.

The tape-recorded data were transcribed in preparation for analysis. The transcripts were read thoroughly in order to discover codes and emerging themes. A thorough reading of the transcript was done in order to check for irrelevant data and to facilitate the organisation of the data into meaningful chunks of information. A "coding" system of data was developed in order to organise data. Jessop (1997:89) defines coding as a complex process which the researcher labels units of meaning or categories according to system of codes, usually developed through a close reading of data. Thorough reading of data was done and questions asked were organised into meaningful topics/codes. The topics identified were the subject's description of his/her world in relation to science, perceptions about a hierarchy of knowledge and skills in teaching and learning science, perceptions about a hierarchy of assessment practices in science.

Biklein (1992) calls these topics/phrases "*coding categories*" and I have used these topics to sort descriptive data I had collected. Tally marks were used in order to find the relevant prevailing categories. The results of this analysis are described in chapter four.

CHAPTER FOUR: FINDINGS OF THE STUDY.

4. 1 INTRODUCTION.

This chapter presents and discusses the findings of the study. I have indicated in chapter three that the data collected were qualitative and quantitative in nature and consisted of classroom observation, document analysis and interviews. Descriptions and quotations of the transcribed data from the interview schedule will be presented first, in order to illustrate and substantiate the assertions made. Biklein (1992) states that in qualitative research, the onus is on the researcher to convince the reader of the plausibility of the presentation, so that what was said to the researcher makes sense to the reader. The quotations from the transcripts are used to bring the reader closer to the subjects.

Analysis of the interview will be followed by analysis of the observation schedules and assessment document. Data from these instruments are presented in the form of graphs for each educator. A brief description of the information contained in each graph is given.

4.2 EDUCATOR "A" -INTERVIEW ANALYSIS.

4. 2.1. Biography.

Educator "A" taught at a well- resourced suburban school. This school presented strong characteristics of functionality. The educator has a Bachelor of Science, Bachelor of Education (Honours) and Higher Diploma in Education as academic/professional qualifications respectively. At the University level, the educator majored in Biology, Chemistry and Botany. Biology and Mathematics were the favourite subjects in both school and University level, while Physical Science was least favoured. The educator has twelve years of teaching experience in previously disadvantaged' and advantaged schools

4. 2.2 Subject's description of her world in relation to Science Teaching/Learning and Assessment.

The interview reveals that while Biology and Maths were the favourite subjects at school, physical science was least favoured. Being analytical, engaged with logical tasks, getting things right, interrelatedness of facts, and concrete learning were the favoured types of learning. This was supported by the educator's description of her tertiary education experiences, in response to the following questions:

Interviewer: *Tell me about the subject that you liked the most while you were at school and in your tertiary education.*

Respondent: *At school most Biology, at the University didn't have any preferences. I enjoyed both my majors, which were Biology and Chemistry.*

Interviewer: *What is it that you liked the most about them?*

Respondent: *I think I liked them because they make sense to me, and everything that is logical makes sense to me. I like to see how things fit together; like in Biology you have so many aspects, which come together to make a person, to make a plant, and different systems and how they are interdependent.*

The educator's perception of science learning provides evidence of concrete learning, interrelatedness of facts. The educator's responses like the following supported this inference:

Interviewer: *What do you find yourself teaching? Do you teach processes as opposed to content?*

Respondent: *I can't say I teach content rather than processes, or processes rather than content, the two are so integrated, inseparable.*

Respondent: *Teaching skills often become integrated with content.*

Respondent: *I think it must make sense to me because if it is a string of unrelated facts that make no sense to me.*

The interview also reveals that assessment practices are targeted at assessing knowledge rather than skills. This was captured from the educator's account she/he gave on assessing different levels of doing/thinking. A response like the following provides supporting evidence:

Interviewer: *How would you assess different levels of doing and thinking in Natural Science?*

Respondent: *By looking at different skills, you can't accommodate different learners. Children acquire skills at different levels, at different times, so with short tasks it becomes so difficult to find a suitable level that you can test everyone.*

Interviewer: *How would you consider that the child is really progressing in his/her learning, that there is evidence of learning?*

Respondent: *Only if you consider developmental path. I do not know how to respond specifically to that question.*

4. 2.3. Perceptions about a Hierarchy of knowledge and skills in Teaching and Learning Science.

With reference to the body of knowledge and skills in natural science, the interview reveals that knowledge and skills are taught in an integrated way. This became evident in the educator's account she gave on her experiences in teaching in natural science. Responses like the following provide supporting evidence:

Interviewer: *What do you find yourself teaching? Do you teach processes as oppose to content or both?*
Respondent: *I don't think you can really separate them too much.*
Respondent: *I can't say I teach content rather than processes/processes rather than content, the two are so integrated. Content without the processes, content is a part of processes*."

However, it is important to note that the educator perceives syllabus as presenting knowledge in an unstructured way. This was contrasted with the old syllabus, which the educator viewed as being structured. In response to the questions asked about educator's experiences in teaching Natural Science, the educator said:

Respondent: *The Biology I used to teach had a well structured syllabus.*
Respondent: *In natural sciences you have so much freedom to do what you think is right.*
Respondent: *It is so unstructured, and because it is flexible, you tend not to stick to. You know, there is no syllabus, so there is no concept.*

The interview also reveals that the educator is unclear about the concept of hierarchy of skills and knowledge, and is unaware that he/she is implementing it. Response like the following gave supporting evidence. In response to the questions asked whether the educator ranks knowledge and skills in her teaching, the educator said:

Respondent: *I should be doing it but I can't say I'm doing it.*
Respondent: *There are skills that are integrated with knowledge.*
Respondent: *Yes, I suppose I suppose I should have organised skills more in a focused way, but I don't.*

The educator's perception of different levels of doing and thinking gave evidence of being unclear about the concept of a hierarchy of knowledge and skills. A response like the following provides supporting evidence:

Respondent: *Oh there must be, the thing is more children are at different levels, you know tasks that one class finds relatively easy, another class finds it exceptionally complicate, it's got to do with their levels.*

The idea of the teaching of skills and knowledge being guided by intellectual demand was evident in the response she gave to the following question.

Interviewer: *If you were to teach skills and knowledge how would you do it"?*

Respondent: *It will depend on you, you have to identify which skills you are working with, you.... at the moment we are doing graphs. Some skills like one of my assessment tools were to select the important information that was the skills, or a learning skill. Next week they to do research on internet, and they are going to, in point form...they have to translate that into point form, which to me is an important skill to be able to select, to analyse.*

The educator in the above quote identifies selection of important information, then analysing information thereafter.

4. 2.4 Perceptions about a Hierarchy of Assessment Practices in Science.

It was evident from the interview that the educator grades questions in accordance with learner intellectual capabilities. But it was not clear that this grading is being guided by hierarchical intellectual demand. This was captured when the educator was challenged to give an example of questions he/she assigns to higher/average/low thinkers. Response like the following provided supporting evidence:

Interviewer: *Can you give practical examples of questions/assessment items that you would use to establish abstract/lower-order learning?*

Respondent*: Higher achievers are able to handle problem- solving questions, indirect, deductive, interpretive questions far more than average children would do.*

The interview also reveals that the educator set assessment criteria, but was unclear about their significance. The educator views setting of assessment criteria as a procedure rather than bearing any significance. A response to the following question gave evidence.

Interviewer: *Do you set assessment criteria?*

Respondent: *Yes, I do as well as rubrics, sort of, yes, okay/not, it is the way it has to be done.*

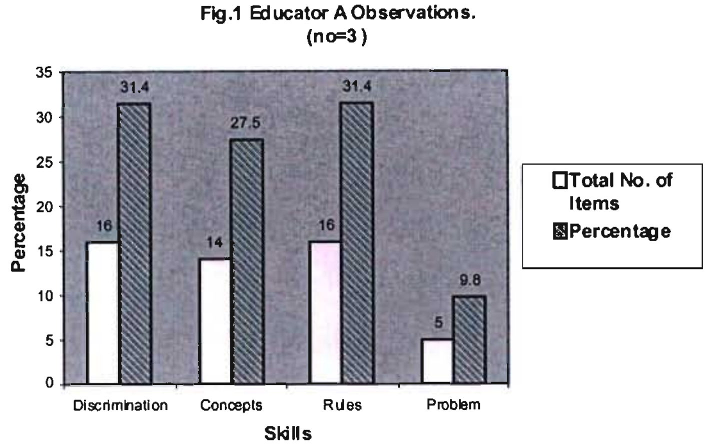
It is important to note that even though assessment criteria are set, sequencing them in any order of importance was not clear. The following response to the following question illustrates the point:

Interviewer: *I have observed that you do set assessment criteria in you class activities. Is there any order of importance in which you develop assessment criteria?*

Respondent*: No I must admit, I do not develop them in any order of importance, I just look at, but in any order of importance I allocate marks to things that are important, that carry more weight than others.*

4. 2.5 Assessment Practices.

4. 2.5.1. Oral assessment (observations).

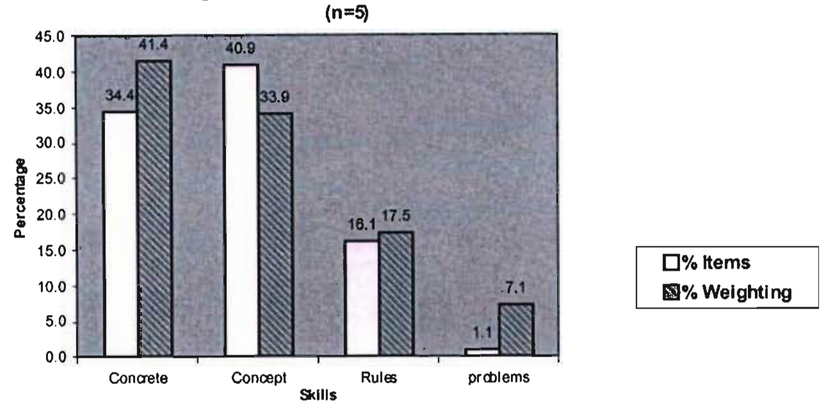


In total, fifty-one question items were analysed from three hours of observations. From Fig. 1 above, it is clear that the most frequently asked question items could be assigned to discrimination or rule categories during classroom interaction. The next highest category was concepts. Very few questions were asked in the problem- solving category.

4.2.5.2 Written Assessment.

(i) Controlled/Class Tests.

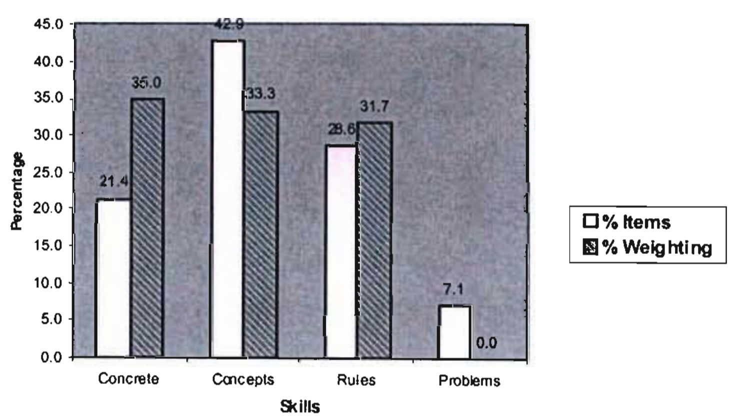
Fig. 2 Educatorl A(controlled Tests)
(n=5)



In total, ninety-three questions items were analysed from five controlled tests. Fig. 2 above shows that most question items (75.3%) could be assigned to concrete or concept categories. These categories together accounted for about 75.3% of marks allocated in controlled tests. There were seven-teen questions items that were assigned to rules or problem solving. These categories could be accounted for about 25% of the marks allocated in controlled tests.

(ii) Worksheets/Exercises/Activities.

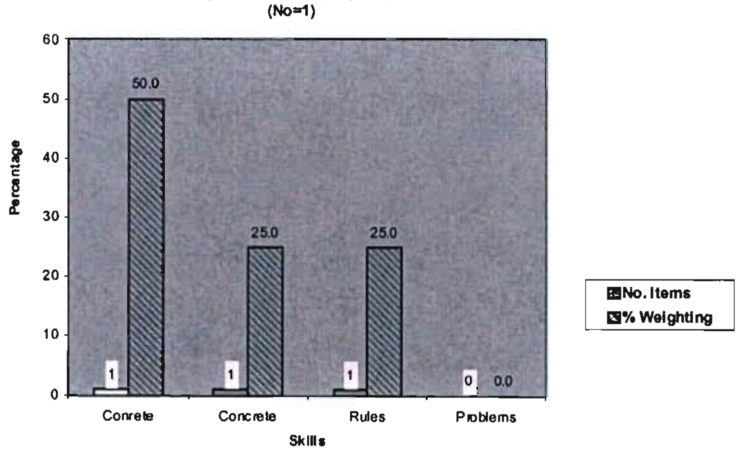
Fig.3 Educator A (worksheets)
(n=3)



Three worksheets were analysed, comprising a total of fourteen question items. Fig. 3 above reveals that the most question items (42.9%) fell in the concept category, accounting for 33.3% of the marks. The next highest question items (28.6%) fell in rules, accounting for 31.7% of the marks. The question items (21.4%) assigned to concrete category accounted for 35 % least of the marks. Problem-solving questions were asked (7.1%), with no mark allocation.

(iii). Projects/Assignments.

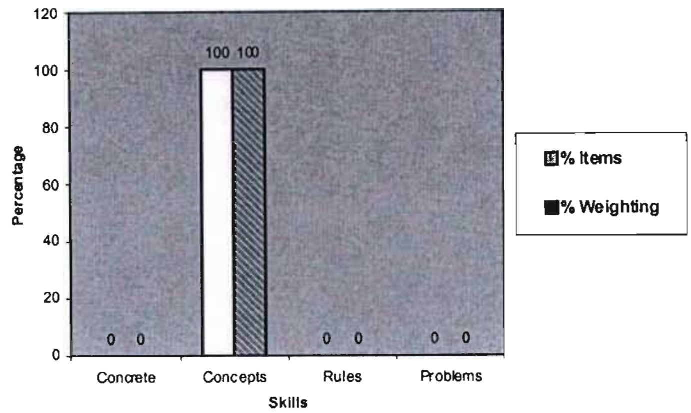
Fig. 4 Educator A (Projects)
(No=1)



In total three question items were analysed. Fig. 4 above reveals that the question items fell in concrete, concepts, or rules categories equally. The concrete category accounted for a higher percentage (50%) of the marks than concepts and rules, which accounted for 25.0% respectively. There were no question items that could be assigned to problem solving skills.

(iv) Essay.

Fig. 5 Educator A (Essays)
(n=1)



Only one question item was analysed here. Fig. 5 above reveals that the question item fell in the concept category. There were no questions that could be assigned to the rest of other categories.

4. 2. 6. General Comments.

The overall educator's assessment strategy is that concepts, discrimination and rules are more frequently assessed than problem solving. This is evident in both oral and written assessment techniques. For example, in oral assessment (observations), out of fifty-one question items that were analysed, forty-six question items could be assigned to concrete, concepts and rules. The remaining five question items could be assigned to problem solving category.

In written assessment, the highest percentage (42.9% in worksheets, 40.9% in controlled tests, 100% in essays) of marks and question items was assigned to concepts. This assessment strategy corresponds with the mark allocation (33.9% in controlled tests, 33.3% in worksheets and 100% in essays). Rule category received the highest percentage of questions in worksheets (28.6%), accounting for 31.7% of marks. Discrimination category received highest percentage (41.4%) in controlled tests, accounting for 34.4% of the mark allocation. It is important to note that little attention was given to problem solving in all assessment tasks.

4.3.EDUCATOR "B" INTERVIEW ANALYSIS.

4.3.1 Biography.

Educator "B" taught at a well resourced- school. This school presented strong characteristics of functionality. The educator has a three- year tertiary qualification from a College of Education. Initially the educator wanted to be a Biographer but didn't like languages. When she went for teacher training, she took Biology. Biology was preferred to History and Geography. The educator does not teach Biology at grade eight all the time. She alternates teaching this subject with Maths. The educator was not exposed to investigative work at school level. The educator has experience of teaching in previously 'advantaged' schools and has taught for twenty-five years.

4. 3.2 Subject description of her world in relation to Science.

The interview reveals that Biology was the favourite subject in schools. Concrete learning was preferred to concept/rule/problem solving learning. This is evident from the educator's description of her school and tertiary education experiences, as in the example below:

Interviewer: *Tell me about the subjects that you liked the most while you were at school and at your tertiary level.*
Respondent: *Obviously Biology.*
Interviewer: *What is it that you liked the most about it?*
Respondent: *It's about plants, tangible staff for me; you can see it is not abstract.*
Respondent: *Learners are interested in practical things.*

The educator's perception of learning in science emphasise concrete learning. For example, responses the educator gave to the following question provide evidence.

Interviewer: *What do you think is the best way to learn in Natural Science?*

Respondent: *Best way to learn/ MMM...I always tell students to read/hear something for several times.*

Respondent: *Biology is part of language, part of vocabulary, so I do emphasise terminology.*

However, the educator assesses knowledge imparted by her with less emphasis on skills. This was revealed when the educator was asked about the major goals of assessment. The educators' response to the following question provide evidence:

Interviewer: *What are the major goals of assessment in Natural Science?*
Respondent: *How much far you have gone with the lesson, are they gaining anything from me or were it a waste of time.*

4. 3.3 Perceptions about a Hierarchy of knowledge and skills in Teaching and Learning Science.

With reference to the body of knowledge and skills in natural science, the interview reveals that teaching knowledge is valued more than teaching skills. This emerges in the educator's accounts she gave of her experiences in teaching natural sciences such as:

Respondent: *It is more difficult to discover something than teach it",* providing evidence of focussing on knowledge rather than skills. This response exposes that knowledge is taught in a teacher centred way rather than learner centred.

It is evident from the interview that there was no clear perception of a hierarchy of knowledge and skills. This emerged when the educator was challenged to rank knowledge and skills.

Interviewer: *How would you rank knowledge and skills in Natural Science?*
Respondent: *Mm…I think in a lot of cases when you are testing or you are giving knowledge, you also at the same time test the skills. I think…we still tend to have more emphasis on knowledge than skills.*

The above is the evidence of the educator's perceptions of different levels of "doing" and "thinking". Responses like the following indicate that the educator lacked a clear concept of a hierarchy of knowledge and skills:

Interviewer: *Do you develop assessment criteria in any order of importance?*

Respondent: *I do not know what you want from me, what do you mean by levels of doing and thinking?*

The educator's responses revealed sequencing of content, but not of cognitive/intellectual demand. This is apparent in educator's response to the questions about ranking of knowledge and skills, and of levels of doing and thinking.

Respondent: *Teach basics (simple) first, and then move on to combining things.*

Respondent: *Like for instance, let me explain it to you, we are doing electrostatics now, when they do not know the atom, they can no longer understand what electrostatics are.*

4. 3.4 Perceptions about a Hierarchy of Assessment Practices in Science.

It was evident from the interview that there was no clear understanding of ranking of questions by intellectual demand. The educator grades questions from simple to more difficult ones, however; it was not clear how she categorises easier/ more difficult questions. Assessment criteria are set but not organised in any order of importance. Therefore the idea of sequencing the criteria does not exist, but that this sequencing is guided by a hierarchical view, is not evident. The following responses support this finding:

Interviewer: *Do you set any assessment criteria?*

Respondent: *Yes!*

Interviewer: *Is there any order of importance that you organise your criteria?*

Respondent: *No.*

Interviewer: *Why? Why? If I may ask you?*

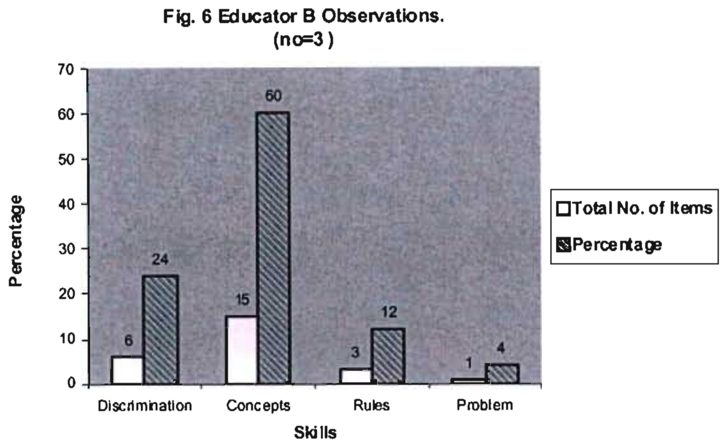
Respondent: *Mm. I do not know. No, no, not so much in grade eight.*

Interviewer: *How would you assess different levels of 'doing' and 'thinking?*

Respondent: *Questions will be graded from easier all the way down to much harder ones.*

4. 3.5. Assessment Practices

4. 3. 5. 1. Oral Assessment (observations).

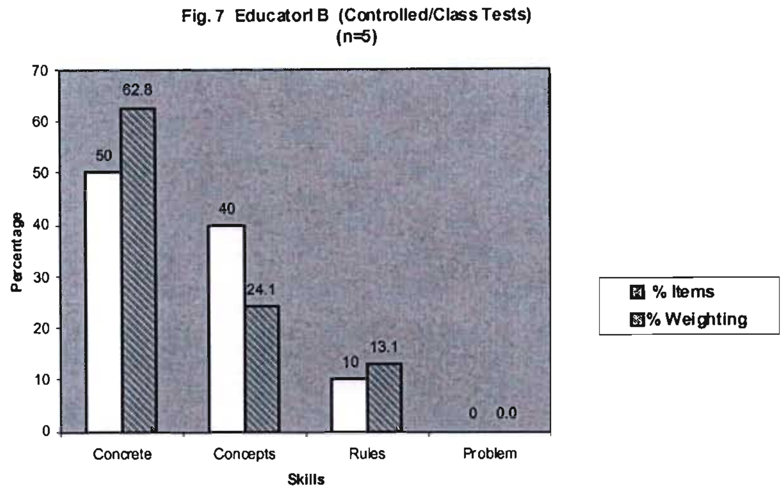


In total, twenty-five questions were analysed in three hours of observations.

From Fig. 6 above, it is clear that the educator asked questions about concepts (60%) more frequently than any other category during classroom interactions with learners. The next highest category was discrimination (24%), with few questions asked in the rules or problem solving categories.

4.3.5.2 Written Assessment.

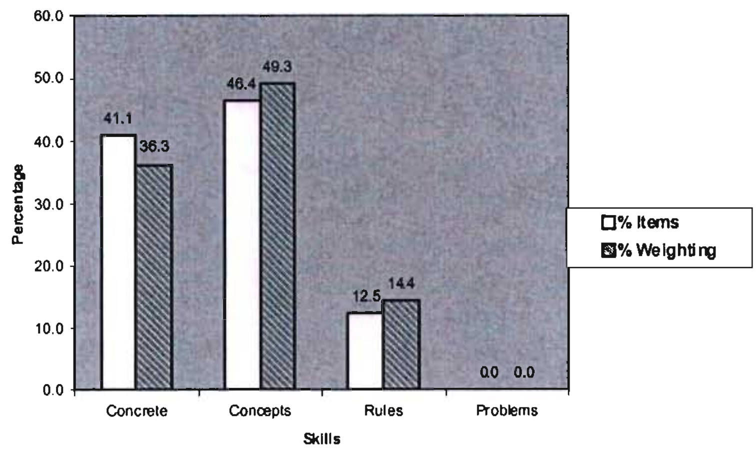
(i) Controlled/Class Tests.



Twenty question items were analysed weighting heavily in favour of concrete questions. Fig. 7 above shows that most of the question items (90%) could be assigned to concrete or concepts. Those two categories accounted for about 87% of the marks allocated in controlled test. 10 % of the question items were assigned to rules and no question items were assigned to problem solving.

(ii) Worksheets/Class Activities/Exercises.

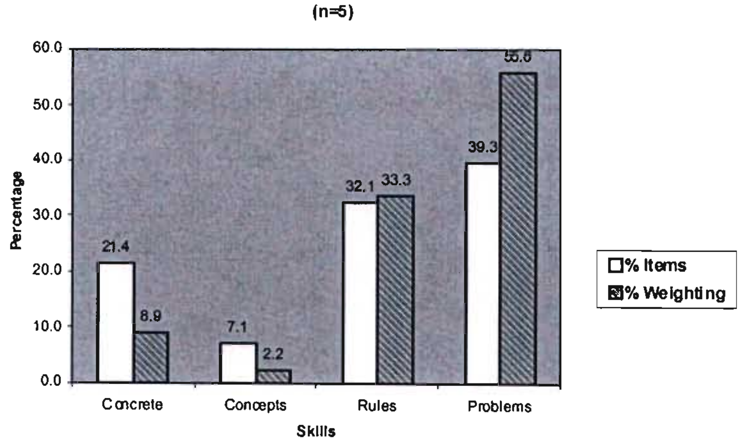
Fig.8 Educator B (worksheets/Class Activities) (n=13)



In total fifty- six questions items from thirteen worksheets, were analysed, weighting in favour of concrete category. Fig. 8 above shows that most of the question items (88%) fell in the concrete or concept categories, accounting for 86% of the marks. There were no questions in the problem-solving category, and a small number (12.5%) in rules, accounting for 14.4% of the marks.

(iii)Projects/Assignments.

Fig. 9 Educator B (projects/Assignments) (n=5)



Twenty- eight question items from six projects/assignments were analysed. Fig. 9 above reveals that more focus was on rules or problem solving category. About 71% of question items and 89% of marks were assigned to these categories. There were few question items (29%) that could be assigned to concrete or concepts and low mark weighting (11%) assigned to these categories. This accounted for 11% of the marks allocated to these categories. In total, twenty-eight question items were analysed.

4. 3. 6 General Comments.

The overall educator's assessment strategy is that discrimination and concept skills are more frequently assessed than rule learning and problem-solving skills. This is evident in oral assessment (observations) and written assessment (controlled tests and worksheets).

For example, during observations, out of twenty-five question items that were analysed, twenty-one of these were assigned to concrete or concept categories, while four were assigned to rules or problem-solving.

In written assessment, the highest percentage (90% in controlled test and 88% in worksheets) was assigned to concrete and concept category, while low/no percentage was assigned to rules and problem-solving categories. The educator's assessment strategy is also reflected in mark allocation (77%) in controlled tests, and 86% in worksheets were assigned to concrete and concept learning.

The projects/assignments as written assessment techniques emphasize rule and problem - solving categories. Less emphasis was put on concrete and concept categories. Out of twenty-eight question items that were analysed, 71% were assigned to rules and problem- solving, while 29% were assigned to concrete and concepts. The educator's emphasis accounts for the mark allocation (90%) assigned to rules and problem solving, while 11% was assigned to concrete/concepts learning.

4. 4. EDUCATOR "C" INTERVIEW ANALYSIS

4. 4.1. Biography.

Educator "C" taught at a well resourced- school. This presented a strong characteristic of functionality. The educator has a Bachelor of Science and majored in Chemistry and Physics.

German was taken as an additional subject. She also has a Higher Diploma in Education. The educator favoured learning about concrete, recent things than the historical events. The educator enjoyed being engaged in project kind of learning, investigative learning. Accountancy and Psychology were the favourite subjects at school and tertiary level respectively. Grade eight natural science teaching is shared with another educator. The educator has taught in both previously "disadvantaged' and "advantaged" schools. The educator has taught for twenty-seven years.

4. 4. 2. Subject's description of her world in relation to Science.

The interview reveals that Accountancy and Psychology were the favourite subjects at school and tertiary education experiences, respectively. Biology was the second favourite subject in both instances. Concrete learning and investigative learning were preferred to learning about the abstract things. This was evident in the educator's description of her school /tertiary education experiences, in response to the following questions:

Interviewer*: Tell me about the subject that you liked the most while you were at school and at your tertiary institution?*
Respondent*: My life at school, I did accountancy first, but I didn't go on with it in my tertiary because I had to do maths and my maths was not very good. So I continued with Biology.*

The educator prefers concrete and investigative learning. For example, response to the following question support this finding:

Interviewer: *What do you think is the best way to learn in Natural Science?*
Respondent: *The best way to learn is to actually experience things. Why? because you remember much more. If you have to do it yourself you remember it. I said to my grades eights you have to investigate bees, percentage air in the soil. They do it themselves.*

It is important to note that the educator says she/he teaches and assesses skills rather than knowledge. The emphasis is directed towards skills. This was revealed when the educator was asked to give an account of the major goals of assessment. The following response illustrates the emphasis on skills:

Interviewer: *In your view, what do you think is the major goal of assessment in Natural science?*

Respondent: *I think in terms of the OBE now it is to give the children instruments, skills they can use later on in life. Instead of just hurling a question and then not knowing how to go about it. It would give them skills where they can go and investigate that and they can branch out. The main objective at the moment is those skills.*

The educator believes that assessment has educational value, but this is not necessarily implemented. This was captured when the educator was challenged to give her view on integration of teaching, learning and assessment, as described in C2005. In response to the questions asked about integrating assessment with learning, the educator said:

Respondent: *The assessment should help the child progress but what do you do in a case where some are progressing and some are not, in a big group.*

Respondent: *What I should be doing is each child should be going at his/ her own pace.*

4. 4. 3. Perception of Hierarchy of knowledge and skills in Teaching and Learning Science.

With reference to the body of knowledge and skills in natural science, the interview reveals that the educator is aware of the body of knowledge that has to be taught, but this is not practically implemented. What the educator teaches is relative to her schooling, tertiary education experiences and the passion she has about the subject. This emerged from her response to the following question:

Interviewer: *"What do you find yourself teaching?"*
Respondent: *"What I find is that, I have to correct this, I lean more to the biology side of natural science than physics and chemistry, and I've got to try and get away from that. I've got to integrate the two."*

Respondent: *Because I am a biology teacher I do tend to favour the biology and I must not do that…*

Respondent: *And Cindy who is also a physics teacher. Whatever we do there, her class discussion goes towards the physical science part.*

However, the interview reveals clearly that skills are more strongly emphasized than knowledge. This was evident in the educator's responses on what she/he perceives as a major goal of assessment, for example:

Interviewer: *What do you think are major gaols of assessment in Natural science?*

Respondent: *I think I terms of OBE now it is to give the children instruments, skills that they can use in life. I would teach them skills where they can go and investigate that and they can branch out.*

It is evident from the interview that the educator holds no clear perception of the notion of ranking of knowledge and skills, but a hierarchy is implemented in practice. This was captured when the educator was challenged to rank knowledge and skills, and to give a scenario where she teaches broad knowledge and skills and then moves to the specifics. In response to the questions asked about the way the educator ranks knowledge and skills, the educator said:

Respondent: *What do you mean how do I rank?*

Respondent: *Sometimes you have to give a bit of knowledge before you go on and do skills, but I think what we are aiming to do now is teach them the skill we discovered which I think is sadly lacking at the moment.*

Respondent: *Well if you looking in terms of the skills and say the experiments on soil, they will start of with composition of soil and they are going to do an experiment where they are going to see all the layers and identify them. Then they have told me in the soil we have air, we have water, humus minerals, then they are going to come down and learn how to measure the percentage air, water, humus, till eventually they will end up with an analysis of a particular soil.*

The educator's perceptions of different levels of doing and thinking indicated that, in her view the act of teaching and learning is guided by a hierarchy of knowledge and skills. This finding is supported by:

Interviewer: *Are there any different levels of doing and thinking in Natural Science?*

Respondent: *There are, like with burning of coal, we started with the causing of pollution and we identified different kinds of pollution, then we went to burning of fossils fuels which is our coal and so on. That took us onto electricity and we learnt how to work out our electricity bill.*

4. 4. 4. Perception about Hierarchy of Assessment Practices.

The interview provides no clear picture of whether the assessment criteria are consistently set/they are educator's original work. A response to this question illustrates this finding:

Interviewer: *Do you set assessment criteria?*
Respondent: *I do try to, I haven't the criteria with me here, but we actually have a rubric at the back,* provides evidence.

A fuzzy idea of setting criteria being guided by intellectual demand does exist in the educator's perception. This was revealed when the educator was asked to give an account on the way she organises criteria when setting them. For example:

Interviewer: *Is there any order of importance in which you organise/set up your criteria, when setting them?*
Respondent: *True/false we mark right/wrong and the definition is right/wrong and then.*

The lack of clarity about organising criteria emerged again when the educator was asked to give an account of the way she assesses different levels of knowledge and skills. Her response was:

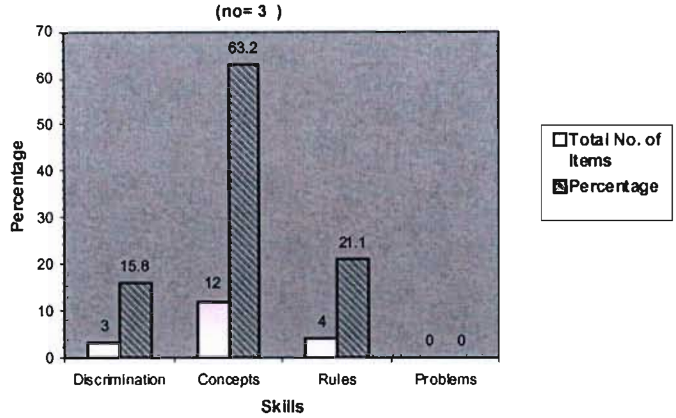
Interviewer: *How do you assess broad/ specific skills? Can you demonstrate that by means of example?*

Respondent: *Very difficult because you are not actually watching the children doing it.*

4. 4. 5. Assessment Practices.

4.4.5. 1. Oral Assessment (observations).

Fig. 10 Educator C Observations (no= 3)

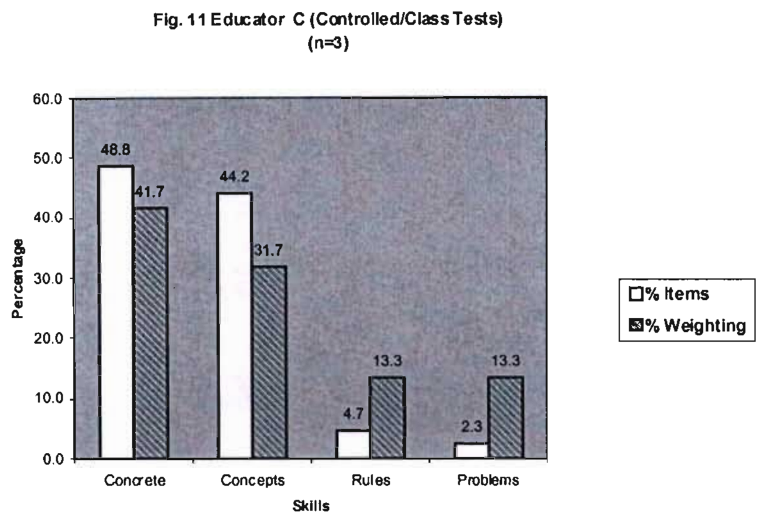


Nineteen questions were analysed from three hours of observations.

Fig. 10 reveals that the educator asks questions about concepts more frequently than any other category during classroom interaction settings with learners (63.2%). The next highest category was rules (21%), followed by discrimination (16%). There were no questions items that fell in the *problem-solving* category.

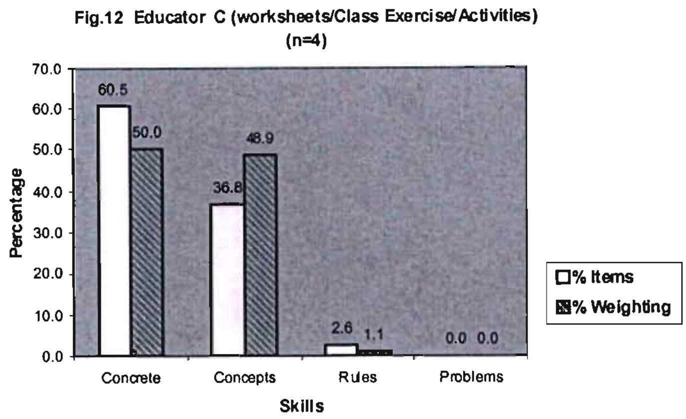
4.4.5.2 Written Assessment.

(i) Controlled/Class Tests.



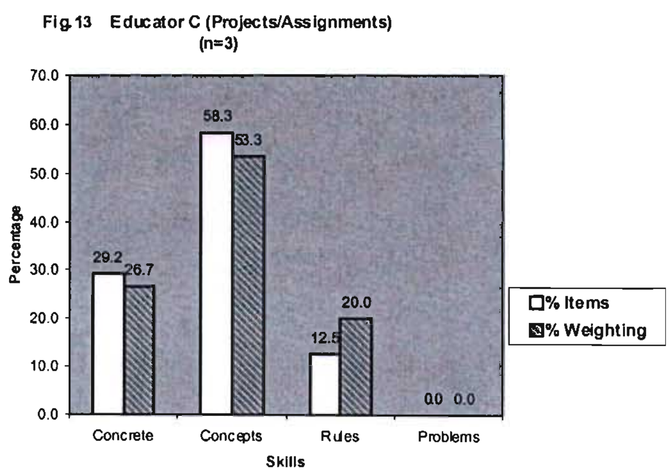
In total forty-three questions items were analysed from three controlled tests. Fig.11 above shows that most of the question items (93%) could be assigned to concrete or concept categories. accounting for about 73% of the mark allocated to controlled tests. There were few question items (7%) that could be assigned to rules or problem-solving categories, accounting for 27% of the marks allocated in controlled tests.

(ii) Worksheets/Class Exercises/Activities



In total, thirty-eight questions items from four tasks were analysed. Fig. 12 above reveals that most question items (97%) fell in the concrete or concept categories, accounting for 99% of the marks. There were no question items that could be assigned to problem-solving category, and a very small number (3%) could be assigned to rules.

(iii) Projects/Assignments.



In total, twenty-four questions items were analysed from three tasks. Fig. 13 above shows that most of the question items (58%) could be assigned to concepts, a higher percentage than any other category, and accounting for about 53% of the mark allocation in projects/assignment. The next highest category was concrete (29%), accounting for about 27% of mark allocation in projects/assignments. Few question items were asked on the rule category (13%), with no question items asked in the problem-solving category.

4. 4. 6. General Comments.

The overall educator's assessment strategy is that discrimination and concept skills are the most frequently assessed skills. This is more evident in written assessment techniques than oral assessment technique.

For example, the highest percentage of questions (93% in controlled tests, 97% in worksheets and 88% in projects) was assigned to these categories. This trend is reflected in marks allocated to discrimination with 73% of the marks in controlled tests, 99% in worksheets, and 70% in projects). While discrimination and concept learning are the frequently assessed categories, the concept category dominates, accounting for 63% of marks. Discrimination and rules received less emphasis, with 21% of question items assigned to discrimination category, and 16% to rule category. Little attention is given to problem-solving category. This was evident in observations, worksheets, and projects, where no question items could be assigned to problem- solving.

4.5.EDUCATOR "D" INTERVIEW ANALYSES

4.5.1 Biography.

Educator "D" taught at an under- resourced school. The school did not present strong characteristics of functionality. The educator has a three-year Senior Secondary Teaching Certificate (SSTC), majoring in Biology and History, and Further Diploma Education (FDE). The educator has sixteen years of teaching experience teaching Biology and History. History has been taught when need arises at school as compared to Biology which has been taught throughout these years. Biology is the favourite taught subject as compared to Physical Science in Grade eight Natural Sciences.

4.5.2 Subject's description of his world in relation to Science.

The interview reveals that Biology was the favourite subject and Physical Science the least liked subject at school. Concrete learning and investigative learning is the preferred type of learning. This was evident in the educator's description of his schooling and tertiary education experiences. For example:

Interviewer: *What is it that you like about teaching Biology?*
Respondent: *I said I like it because it deals with nature, life as whole. So it includes living/non-living organism that includes us, human beings, animals, as well as plants. So that is the main reason why I like this subject. While I was at tertiary level, as I'm teaching now, I'm teaching Biology because I like it.*

The educator's perception of learning in science provides substantial evidence of a preference for investigative learning/inquiry-based learning. The educator's responses to the questions asked about the best way to learn in natural Science, illustrates this finding:

Respondent: *For learners to get more information on their own.*

Respondent: *I think it would be advantageous to the learners because something that you have collected yourself you don't easily forget it, so they will be able to do it, in the future they will be able to make research, to analyse that information that they have collected, and come to interpret it as well as come to conclusion.*

The educator assesses both investigative skills and knowledge. This was revealed when the educator was asked to give an account of what he considers to be the evidence of student's scientific learning. The following responses illustrate the educator's view:

Interviewer: *What can you regard as evidence of learning in Natural Science?*
Respondent: *I think you can see that a learner has grasped most of the information that you have given him or her when he or she can collect that information, when she/he can not only write it on paper, but can still tell you verbally. Students, for example, after we had learnt digestive system, you would hear them saying to me during break time when I'm having lunch, oh sir, you are eating a lot of carbohydrates, you are getting vitamins from fruits, and*

so on. So once the learner can recall something that he/she has learnt, that shows that a very good understanding of that concept.

Educator "D" perceives evidence for students' learning as when a learner is able to apply acquired knowledge in a real life situation.

4.5.3 Perception about a Hierarchy of knowledge and skills in Teaching and Learning Science.

With reference to the body of knowledge and skills in natural science, the interview reveals that less emphasis is put on knowledge. This became evident in the educator's account he/she gave on his/her experiences in teaching natural science. For example:

Respondent: *Concerning learners, since this new system that we are using involves learners more than teachers, so I give them something that they can go and collect information on and they are very interested in it.*

It was evident from the interview that there was no clear perception of the notion of hierarchy knowledge and skills, only a fuzzy idea existed. This was captured when the educator was asked to rank skills/knowledge. The educator responded as follows:

Respondent: *I don't wherether I quote from one activity. We were doing the experiment on combustion. The main aim was to demonstrate that substances could burn in the presence of air. So I wrote the word substance and it was just saying substance can burn in the presence of air, and then organise them into groups, I wrote instructions that they were supposed to follow.*

This response shows that the educator interpreted a hierarchy of skills and knowledge as an ability to follow instructions and tasks as expected.

The educator's perception of different levels of doing and thinking revealed an unclear idea about a hierarchy of knowledge and skills. The educator interpreted this capability as mastery of skills, and their applicability to real life situation. Educator's response to the following question illustrates this finding:

Interviewer: *In your perception are there any levels of doing and thinking in Natural Science? Can you demonstrate your perception by means of examples?*
Respondent: *So in fact the person who is not good in maths can't do this and he/she will experience problem, so the thing is, you cannot say all learners can master that part of electricity, according to their mathematical understanding/level.*

From the variety of responses that the educator gave, it is clear that the sequencing of content is important. This revealed itself as an act/attempt to establish existing knowledge before embarking on a new task. The response like the following captures the evidence:

Interviewer: *What do you think is the best way to learn in Natural Science?*

Respondent: *For learners to go and get information on their own, as a science teacher I used to give them something before we even begin we had a discussion with them to try and find out how much they know about the whole topic.*

The extent to which this act/attempt is driven by intellectual demand is not clear.

4. 5. 4 Perceptions about Hierarchy of Assessment Practices

The interview reveals that the educator does not grade questions in accordance with a hierarchy of knowledge/skills. The setting of questions is not clearly guided by the intellectual demand. This was evident when the educator demonstrated the way he/she would assess different levels of doing and thinking. The educator responded as follows:

Interviewer: *In developing your assessment tasks, do you rank questions in any order of importance?*

Respondent: *So really the question for the young ones, like ask something, those questions that are more leading questions, you can start from there, that is the starting point. And then if you see they are coming right you move on now to this problem solving.*

However, it is important to note that the grading/setting of question items was more associated with learner capability, which does not in fact indicated a clear perception of a hierarchy of knowledge and skills. This became evident when the educator was asked to give examples of questions he would assign to slow/above average learners. The response was:

Respondent: *For slow learners, questions with formulae, where they can make reference would be given. For above average learners, questions without referencing are appropriate.*

The interview also reveals that the educator is not clear on the notion of assessment criteria, or on setting them. Educator's responses to the questions asked about setting/developing assessment criteria support the findings.

Respondent: *Ya.... are you referring the tools after having given learners criteria?*
Respondent: *In OBE there are many things that the educator can set in activities.*

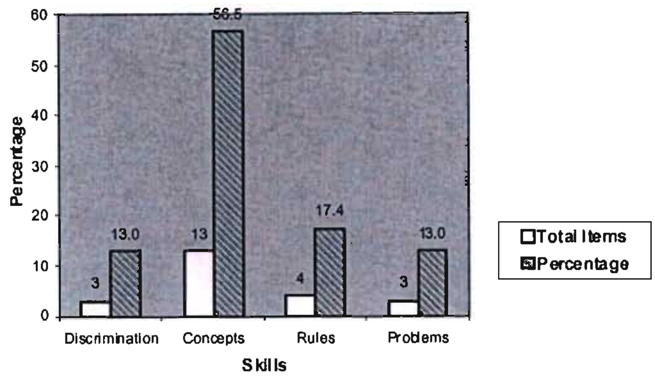
Likewise, the idea of sequencing assessment criteria does not exist. The educator is unclear about organising/setting criteria on the basis of a hierarchy of knowledge and skills. A response to the following question supports the interpretation:

Interviewer: Do you organise assessment criteria in any order of importance?
Respondent: *It depends on the activity that you give them, so activities drives you towards what you need from learners, like for instance, one of my activities was on the candles. My assessment was to establish wherether learners were able to follow instructions, which involve listening, and reading instructions with understanding.*

4.5.5. Assessment Practices.

4.5.5.1 Oral Assessment (observations).

Fig.14 Educator D Observations
(n=3)

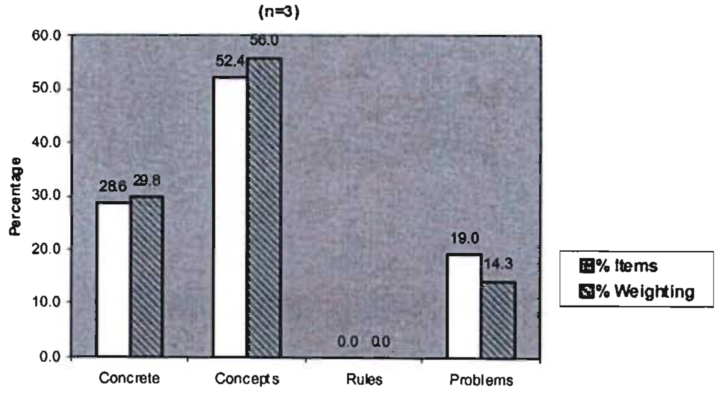


In total twenty-three question items were analysed from three hours of observations. Fig. 14 above reveals that the most frequently asked question items were ascribed to concept learning (57%). The next highest category was rules (17%). Fewer question items fell in the problem-solving and discrimination categories (13%), respectively.

4.5.5.2 Written Assessment.

(i) Controlled/Class Tests

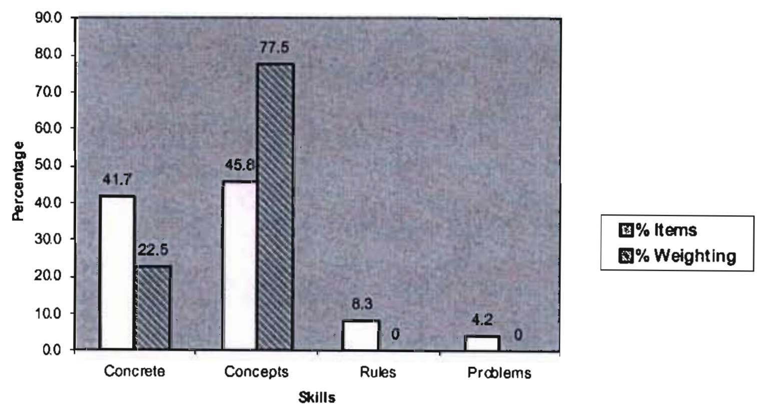
Fig. 15 Educator D (Controlled /Class Tests)
(n=3)



Twenty-one questions items from three tests were analysed. Fig. 15 above reveals that more question items (52.4%) could be assigned to concepts category, accounting for 56% of the marks. The next category (29%) was concrete category, accounting for 30% of the marks. Few question items (19.0%) were assigned to the problem –solving category accounting for 14%. There were no question items that could be assigned to rules.

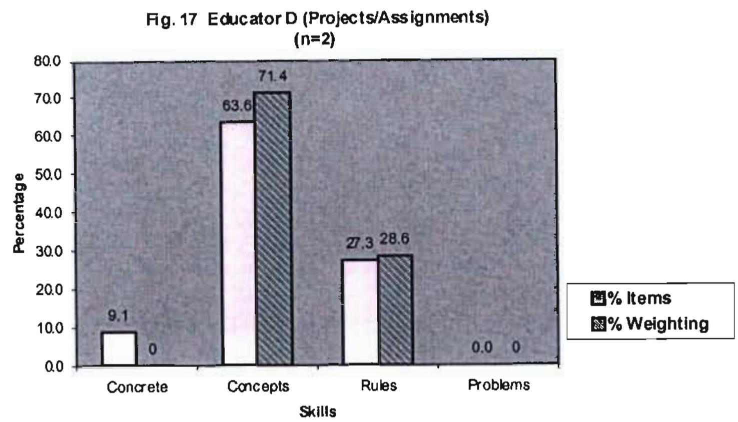
(ii) Worksheets/Class Exercises/Activities.

Fig. 16 Educator D (Worksheets/Class Activities) (n=4)



Twenty-four questions were analysed from four tasks. Fig. 16 above shows that most of the question items (87.5%) fell on concrete or concept categories, accounting for all of the marks allocated to worksheets. There were few question items (13.5%) that could be assigned to the rules or problem solving categories, accounting for 0% of marks allocated to worksheets (the reasons for this were not known).

(iii) Projects/Assignments



In total eleven questions items from two tasks were analysed. Fig. 17 above shows that the educator asked questions that could be assigned to concepts (64%) far more frequently than other categories. This category accounted for 71% of marks allocated to projects. The next highest category was rules (27%), which accounted for 29% of the marks allocated in projects. Few question items (10%) were asked in the concrete category, with no questions asked on problem solving skills.

4. 5. 6. General Comments.

The overall educator's assessment strategy is that concept skills are more frequently assessed than any other skills. This is evident in all assessment techniques, be it oral or written.

For example, in oral assessment (observations), out of twenty-three question items that were analysed, thirteen items were assigned to concepts, while less question items (10) were assigned to rules, discrimination or problem solving.

In written assessment, the highest percentage of question items (52.4% in controlled tests, 46% in worksheets, and 65% in projects) could be assigned to concept category. The educator's emphasis on concept learning is supported by the highest percentage of marks allocated in written assessment (56% in controlled tests, 71% in worksheets and projects).

CHAPTER FIVE: DISCUSSION AND INTERPRETATION OF THE RESULTS

5.1 INTRODUCTION.

This chapter draws together the results of the four cases in the previous chapter. The discussion of these results is organised on the basis of the research framework, which is outlined in chapter three. This chapter serves the following three key functions: to compare and contrast the results in order to understand each educator's perceptions and their assessment practices, to discuss the results in the context of studies reviewed in chapter two, and to make recommendations for assessment practices. Interpretations and themes are extracted from the study in an attempt to answer the following critical research questions raised in the first chapter.

- What perceptions do educators hold in relation to the hierarchy of knowledge and skills?
- To what extent were educator's assessment tasks based on a hierarchical view of knowledge and skills?
- To what extent do these educator perceptions influence their assessment practices?

The educator profiles will be discussed within the context of these research questions. Each educator's biography will be discussed first, followed by the discussion of the results for each case. The discussion draws from interviews that elucidate document analysis and classroom observations mapping educator's assessment practices.

5.2 EDUCATOR A

5. 2.1 What is the Case with this Respondent?

With reference to the first critical question, the data analysis reveals that the educator was unclear about the conception of hierarchy of knowledge and skills. Evidence was captured from answers he/she gave about questions relating to different levels of doing and thinking. The way the educator grades questions, i.e. in accordance with learner capabilities, provides substantial evidence of a hierarchy of knowledge and skills. But this grading was not based on hierarchical intellectual demand. The educator was unable to sequence assessment criteria in any order of importance, providing substantial evidence of the educator's unclear conception about hierarchy. However, the educator was unaware that he/she was in fact implementing a hierarchy of knowledge and skills. The educator's practice of teaching skills and knowledge revealed recognition of a hierarchy of skills and knowledge, as observed in her classroom practices.

Educator A taught knowledge and skills in an integrated and unstructured way. This was supported by the views expressed in the educator's description of her world in relation to science, and her practical experiences. In relation to a hierarchical spectrum, emphasis was placed on concrete learning, and assessment practices were targeted at assessing knowledge rather than skills.

The educator's assessment strategy recognises a hierarchical spectrum of knowledge and skills to some extent. This was revealed in both oral and written assessment tasks. For example in oral assessment, discrimination, concept and rule categories were more frequently assessed than problem solving category. Concept/discrimination categories were the most frequently assessed categories in written assessment. Problem solving received no attention in both instances.

While the interview reveals an unclear conception about a hierarchy of knowledge and skills, the findings show that the educator's assessment tasks were based/guided by a hierarchy of knowledge and skills. The knowledge/skill emphasised was not based on whether the assessment was informal/formal.

What emerged from the analysis was the issue of time allocated to execute an assessment task. The degree of freedom granted to the learner seemed to determine the type of knowledge and skill within hierarchical spectrum. The more classroom-based was the assessment task, the more discrimination/concepts were assessed. These categories were frequently assessed in both controlled oral/written assessment tasks. Rules were frequently assessed in the assessment tasks where learners had more freedom of referencing. This became evident in worksheets and projects where the rules received the highest percentage of marks.

A disjuncture exists between the educator's perception and what she assesses in practice. The educator has an unclear perception of the notion of hierarchy, however, in her assessment practices the educator implements assessment of a hierarchy of intellectual knowledge and skills. The educator's assessment strategy recognised discrimination and concepts/rules, with no emphasis on problem solving.

5.3 EDUCATOR. B

5.3.1What is the Case with this respondent?

With reference to the first critical question, the data analysis reveals that the educator has an unclear perception of a hierarchy of knowledge and skills. This became evident when the educator was unable to rank knowledge and skills by intellectual demand. Further evidence was provided by the educator's inability to categorise questions on the basis of hierarchical intellectual demand. Categorisation of questions was from simple to more difficult ones, which does not correspond with a hierarchy of knowledge and skills. Substantial evidence was gained from the way the educator organised assessment criteria, i.e. assessment criteria were not set in any order of importance. What emerged was a mere sequencing of content but not of cognitive intellectual demand.

It is important to note that, the educator values teaching content more than skills. This became evident in the educator's explanation she gave about her practical experiences of teaching. Response like the following supports this view.

Respondent: *It is more difficult to discover something than to teach.*

Educator B believes that the major goals of assessment are to determine what knowledge learners have acquired. With reference to a hierarchy of intellectual knowledge and skills, and as a major focus of the educator, teaching concrete things, that is, discrimination learning, is what the educator values.

Contrary to what the educator teaches, that is the focus was more on content than skills, the findings reveal that in practice the educator assesses discrimination, concept, and rules categories more frequently than the problem solving category. In practice, the educator applies a hierarchy of knowledge. The highest percentage of question items and mark allocation were assigned to discrimination, concepts and rules. This was evident in both oral and written assessment tasks, but was emphasized in classroom-based assessment tasks, where learners had limited opportunity to reference. Problem solving and rule learning received more emphasis in assessment tasks where learners had more opportunity to reflect on resources and more time to tackle the tasks.

The more informal the assessment technique was and more time allocated to it, the higher the order of skills assessed. In classroom-based/formal assessment, the lower order skills were assessed.

A disjuncture existed between the educator's perception and how she actually assesses in practice. This can be captured from the perception that the educator holds and from her assessment strategies. While the educator demonstrated an unclear perception of the notion of a hierarchy of intellectual skills and knowledge, she believed in teaching concrete knowledge. In practice it is the knowledge that could be assigned to a hierarchically lower level of intellectual skills and knowledge that was the most frequently assessed category. The perception that the educator holds seemed to have little impact on what he/she assesses. While it is evident from the findings that the educator believed in concrete learning, and that knowledge/content could be taught, her assessment practices demonstrated the use of a wide variety of intellectual skills.

What emerged was that the time allocated to tackle each assessment task, weighting and what was possible, guided the educator's assessment practices.

5.4 EDUCATOR C.

5.4.1 What is the Case with this Respondent?

With reference to the first critical question, the findings reveal that the educator holds no clear perception of the notion of ranking of knowledge and skills, but this is practically implemented. The unclear perception the educator holds about hierarchy as opposed to its applicability is revealed in his/her practical experiences.

The data analysis revealed that the educator prefers concrete learning and investigative learning, teaching and assessing skills (whether these skills are intellectual/practical, is not explicitly revealed from the findings). While the educator is aware of the body of knowledge to be taught, skills were emphasized. This is evident in her emphasis on investigative learning, which suggests that the focus was on skills. Again, what becomes unique about this educator is that assessment was perceived as having educational value. This was evident in the educator's description of his/her world in relation to science.

The results show that the educator's assessment tasks placed more emphasis on concrete and concept skills, than on rules/problem-solving. This was revealed in both controlled tests/worksheets, and observations/projects respectively. Therefore the educator used assessment tasks based on a hierarchical view of knowledge and skills to a certain extent. This substantiates the educator's recognition of hierarchy as opposed to his/her unclear perception of this notion.

Whether or not the assessment task was formal/informal, allowing more time for referencing or not was not an issue in the educator's assessment strategy.
Time allocated to execute assessment tasks did not become a determining factor as to what categories of hierarchy could be assessed.

While the interview reveals that the educator was unclear about the notion of hierarchy, his/her assessment tasks did recognise some categories of a hierarchical spectrum. This reveals that a disjuncture exists between the educator's perceptions and about how she assesses in practice. The perception she holds does not necessarily influence her assessment practices.

5.5 EDUCATOR D.

5.5.1 What is the Case with this Respondent?

Arising from the data analysis, the findings reveal that the educator holds an unclear perception of a hierarchy of knowledge and skills. The educator perceived hierarchy to be the ability to follow instructions and tasks as expected. The interpretation that the educator gave for different levels of doing and thinking substantiated this view. The educator interpreted different levels of doing and thinking as the ability to master skills and to apply these skills to a real life situation.

It is evident from the data analysis that the educator grades question not on the basis of hierarchy, but on the basis of learner capabilities. It is important to note that the educator favoured concrete types of learning and investigative learning. In relation to assessment, the data analysis reveals that the educator assesses investigative skills rather than intellectual skills.

In response to the second critical question, the document analysis reveals that the educator assesses 'concepts' more frequently than concrete or rules or problem -solving. This was evident in both oral and written assessment techniques. The educator's emphasis on one category within the hierarchical spectrum did not reflect his awareness of a hierarchy of knowledge and skills. What emerges is that a hierarchy of knowledge and skills did not guide that educator's assessment tasks. Supporting evidence is provided by the manner in which the educator developed assessment criteria, that is assessment criteria were not ranked in terms of hierarchy of knowledge and skills.

The unclear perception that the educator holds about a hierarchy of knowledge and skills seemed to have influenced the way he develops his assessment practices.

5. 6. INTERPRETING RESULTS AND EMERGING THEMES.

The interpretation of the results will be done within the context of a hierarchical view of knowledge and skills as the theoretical framework informing this study. In chapter one and two I have argued that Gagne (1992), Bloom *et al*, (1956), Piaget (1964) agree that science learning should assume a hierarchical spectrum. In chapter one I have argued that if a hierarchy of knowledge and skills is widely recognised by most theorists, assessment practices must incorporate this hierarchy of knowledge and skills, since assessment is part of the learning processes.

5.6.1 First Critical Question: What perceptions do the Educators hold in relation to a theory of a hierarchy of knowledge and skills?

All four educators had an unclear perception of the notion of a hierarchy of knowledge and skills. Contrary to the unclear perceptions that the respondents expressed, their assessment practices recognised various categories of a hierarchy of knowledge and skills, the lower order categories within the hierarchical spectrum being the most common ones. These are the assessment of discrimination, concepts and rule categories. Little attention was given to problem solving across all the respondent's assessment tasks. A focus on concrete learning was a common trend among all respondents.

The recognition of hierarchical categories in science learning is not limited to four respondents studied. Newton (2000) is quite explicit about the notion of a hierarchy in learning science as he argues that:

"...Hierarchical structured learning tasks that target learning and behavioural objectives can be useful when specific facts and skills are desired"(pp184).

Newton (2000) further states that the recognition of a hierarchy of knowledge and skills allows lessons and activities to be planned and structured in a sequential and progressive way. According to Newton (2000), engaging learners in an investigative work that assumes this investigative pathway will enable learners to think and work like scientists (pp 41).

An emphasis on concrete learning and investigative learning in science is not restricted to the respondents studied. This is consistent with what Newton (2000) values; for example, he argues that:

"Younger children need to explore and experience things which are both concrete and meaningful to them" (pp29). Newton continues to state that: *"scientific investigation is the only type of activity through which children develop their abilities to think and work scientifically" (pp 41).*

All four respondents value concrete learning and investigative learning as the major focus of scientific learning. Despite agreement among the respondents on the importance of concrete learning, they differed in certain details, two respondents emphasized concrete learning and investigative learning. The remaining two respondents disagreed. One respondent favoured teaching content rather than the skills, while the other respondent favoured teaching knowledge and skills in an integrated way.

The reader should be reminded that what the respondents value as a major focus in science learning bears no significance to the study. I find it necessary to highlight this, as this presents itself as a critical emerging theme. Of importance is whether their conception of learning is based on a hierarchical view of knowledge and skills. Learning as assuming a hierarchical pathway is not clearly evident in each respondent's conceptualisation. This is at odds with a scientist's strong recognition of hierarchy in learning science as revealed in Gagne et al (1992: 55) and Bennett (2003) reviewed in Chapter Two of this dissertation.

5.6.2 Second Critical Question: To what extent are Educators' Assessment Practices based on the theory of a hierarchy of knowledge and skills?

In chapter two I reviewed the literature on the role of a hierarchy of knowledge and skills in assessment (Eylon et al: 1989, Hodson: 1993, Newton: 2000, Fairbrother: 1988). The Revised National Curriculum Statement for Natural Science Grade R-9 (2002) recognises a hierarchy of knowledge and skills in assessing scientific learning throughout the levels. For example, in the construction of scientific knowledge as learning outcome two, recalling meaningful information and categorising information is applicable to Grade four through to Grade nine level, while interpreting information and applying knowledge only applies from Grade seven to Grade nine (pp 20-21). The complexity of the expected performances increases with the levels.

In this study assessment strategies seemed to be consistent with what the literature values, that is, a wide range of a hierarchical categories was recognised. These are the discrimination, concept and rule categories. However, lack of attention to the problem-solving category existed in all respondent' assessment strategies. Perhaps it is because these educators were all teaching Grade eight, therefore they couldn't really be expected to do much of the problem-solving tasks.

It is relevant that the respondents did not organise categories in any order of importance. The respondent' assessment strategy seemed to be at odds with Fairbrother's (1988) recognition of a hierarchy in assessing students. Fairbrother (1988) argues that assessing skills depends upon one's view of how skills develop as most people adopt a developmental view as opposed to a dichotomous view. The developmental view, Fairbrother (1988) argues, assumes that students are positioned somewhere in the continuum of increasing competence. Fairbrother (1988) highlights that developmentalism seems to be riding high and tends to govern the models of teacher assessment of practical work in the G C S E.

5.6.3 Third Critical Question: To what extent do Educators' Perceptions influence their Assessment Practices?

Based on these regular trends/patterns and irregularities as described above, a disjuncture presents itself as an emerging issue between the respondents' perceptions and their assessment practices. A disjuncture is common to three respondents, while the remaining one seemed to demonstrate correspondence between perceptions and practices. However, the respondents' assessment strategies were not necessarily based on a hierarchical view of knowledge and skills, even though their assessment tasks could be assigned to categories of hierarchy.

Within the context of this critical question and the theoretical framework informing the study, it is necessary to explore the extent to which respondent's assessment strategies were influenced by the perceptions they hold about scientific learning. Fairbrother (1988) presents evidence that educators in England and Wales adopt holistic and atomistic approaches in teaching scientific practical work, as do their assessment practices. The perception the educators hold is that while the focus should be on learning generalised skills, direct clearly defined specific skills should receive attention as well. That is, learning in science ranges from the general level to the specific level, and so should the assessment practices.

Fairbrother (1988) is of the opinion that we teach and assess generalised and transferable skills in science, the focus being on processes. Fairbrother's (1988) conception of learning and assessment seems to be consistent with the kind of assessment practices that have been adopted in South Africa. I have argued in chapter one that educator's assessment practices will have to reflect the processes of scientific learning if it is to be educative as expected by the Revised National curriculum statement for Natural Sciences. In this sense a hierarchy of skills and knowledge must be explicitly recognised. In England educators' assessment practices must identify that progress has been made and ensure that further progress is made.

It is clear from the findings of this study that the respondents' assessment practices are not necessarily influenced by the perceptions they hold. The respondents studied had a limited understanding of the notion of hierarchy of knowledge and skills, yet in practice categories of hierarchy were recognised and practically implemented in their assessment practices.

One wonders whether, if what emerges out of the cases studied is common to other educators in South Africa, assessment practices in Natural Science will ever serve their educative value. The cases studied present an unclear perception of hierarchy, and contrasting ideas existed among them as to what constitutes science learning, yet in practice categories of a hierarchical spectrum were randomly recognised, not following the hierarchical path. The intention of this study was not to generalise about the findings, but an attempt to treat the uniqueness of the individual case and context as important to understand assessment perceptions and practices. The researcher therefore cannot generalise about the findings.

CHAPTER SIX: CONLUSIONS AND RECOMMENDATIONS.

6.1 INTRODUCTION.

This study investigated educators' perceptions about science learning and the influence of their perceptions on classroom assessment practices. In chapter one, I have indicated that this project was primarily interested in Grade eight science educators' assessment strategies in Kwazulu-Natal. Observing educators' lessons, analysing educators' assessment documents and interviewing educators achieved this.

This study was informed by the theory of a hierarchy of knowledge and skills. In Chapter Two I have indicated that this study has adopted a cumulative nature of learning as one of the dimensions of learning as a complex phenomenon. I have argued that the cumulative nature of learning locates learning as operating in a hierarchical spectrum. The Revised National Curriculum Statement Grade R-9 Natural Science (2000) advocates "*process skill*" learning in science. In chapter one I have argued that if "*process skill*" learning has been adopted in learning science, it must recognise a hierarchical view of learning.

One of the aims of the study was to explore the extent to which educators' assessment strategies are influenced by the perception they hold in relation to the theory of hierarchy of knowledge and skills in science learning. Through interpreting the accounts the educators gave about science learning and analysing their assessment strategies, the study revealed that there was no correlation between the educators' perceptions and their assessment strategies (educators were unclear about the notion of hierarchy, yet in practice their assessment tasks randomly recognised various categories of a hierarchy of knowledge and skills). This chapter therefore briefly reviews the findings and suggest recommendations for practice and policy purposes, as well as areas of further research.

6.2 Policy Recommendations.

One of the aims of the study was to explore educators' perceptions about science learning in relation to hierarchy of knowledge and skills. The findings revealed that all educators were unclear about the notion of hierarchy of knowledge and skills. But contrary to the unclear perception that the educators expressed, their assessment strategies recognised various categories of hierarchy of knowledge and skills, the lower ordered categories within a hierarchical spectrum being the most common ones. Across all four respondents, lack of attention was given to problem-solving category. This therefore leads to the following recommendation

(a) While it is clear that the Revised National Curriculum Statement Grade R-9 Natural Science (2000) is underpinned by the notion of hierarchy of knowledge and skills as discussed in chapter one and two, it does not explicitly review the theory underpinning it. This remains unknown to some educators, as is the case with the respondents studied. Justification must be made as to why the Revised National Curriculum Statement for Natural Sciences advocates a *"process skill"* approach in learning science, which in fact suggests the notion of a hierarchy of knowledge and skills as I have argued in chapter one. If the policy is not explicit about the theory that underpins it, not every educator will be able to reach this high level of abstraction. If this occurs, assessment practices may not serve the purpose of promoting science learning as expected.

(b) There is a possibility that the *"process skill"* approach adopted in science learning is interpreted differently by educators. For example the *"process skill"* approach is likely to be interpreted as an approach that enables the achievement of outcomes as opposed to the theory of a hierarchy of knowledge and skills underpinning the curriculum statement and formative assessment practices. In Chapter Two I have argued that both formative assessment and the notion of a hierarchy of knowledge and skills recognises the developmental stages of a learner, in this way assessment is meant to serve an educational value.

The suggestion therefore is that the policy must be explicit about the fact that the expected performances within the learning outcomes are organised around the notion of a hierarchy of knowledge and skills. This will make it clear to science educators that assessment must be integrated with learning.

(c) Induction programmes in the form of workshops organised by education training centres should be held regionally in order to sensitise educators about the theory underpinning science learning, and linking this with expected performances per grade. This will benefit the educators in the sense that educators will be empowered and their understanding of the notion of integration will be extended. The educators that participated in this study are well educated, and work at functional schools, yet they presented unclear perception of a hierarchy of knowledge and skills. Without extensive retraining, assessment practices in science learning will be disabled, i.e. it will not necessarily promote science learning.

In terms of national education policy assessment practices in South African education should form an integral part of learning (promote learning). Lack of explicit knowledge of the notion of a hierarchy of knowledge and skills presented by the respondents in this study have a bearing in their assessment practices. It is likely that the educators will not be sure of the sources of difficulties presented by the learners. It is also likely that the educators will not be sure of what the learners are ready/not ready to learn. This is not to suggest that learners are not progressing in science. It was important to explore the educators' perceptions in relation to a hierarchy of knowledge and skills since the literature has been informative about the notion of a hierarchy of knowledge and skills underpinning the revised National Curriculum statement for Natural sciences. This formed part of the critical research question that I intended to investigate.

6.3 Further Research.

This study has indicated a disjuncture between the respondents' perceptions and their assessment practices in relation to the theory of hierarchical view of knowledge and skills. The study revealed that while the respondents expressed an unclear perception of the theory of hierarchy of knowledge and skills, in practice, the educators recognised a range of categories of hierarchy in a haphazard way.

(a) Using the theoretical framework employed in this study, further research is needed to determine the sources of the unclear perception of the theory of a hierarchy of knowledge and skills. The research has to be designed with the aim of exploring the extent to which the educators' unclear perception on the theory of a hierarchy of knowledge and skills is related to their academic level.

(b) Further research is also needed to determine the sources/basis of educators' acts of organising assessment tasks recognising various categories of a hierarchy of knowledge and skills in a haphazard way. The focus would be to explore the basis of organising the assessment tasks in this way.

(c) Further research is needed to explore the extent to which the educator's lack of understanding of the notion of a hierarchy of knowledge and skills affect learners.

6.4 Concluding Remarks.

The findings of this study may be useful to the General Education and Training Phase Natural Sciences Educators, Further Education and Training Life Sciences& Physical Sciences Educators, planners, policy-makers, and to the educators as practitioners themselves. To the practitioners, they will be empowered to view assessment as an integral part of learning, and they will get to comprehend the theory underpinning a *"process skill approach"*. By knowing and understanding the theory that underpins the Revised National Curriculum Statement, the educators will gain insight in the manner in which to design/develop their assessment tasks. The study will benefit the policy-makers as it highlights the gap between what was intended and what actually happens in practice

Thus, in fields like Natural Sciences, if the respondents' assessment practices are not necessarily informed by a hierarchical theory of knowledge and skills contrary to what is evident in the Revised National Curriculum Statement Grade R-9 (2000), assessment practices in this field are vulnerable to disablement.

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APPENDIX "A"

OBSERVATION SCHEDULE

DATE:

CLASS: LESSON: EDUCATOR:

TYPE OF SKILL	DISCRIPTION OF SKILL	EVIDENT	NOT EVIDENT	COMMENTS
1. Discrimination learning	Teacher's assessment task explores evidence of explanation of events, objects, shapes, sizes (i.e. declarative knowledge)			
2. Concept Learning.	Teacher's assessment tasks: (i) Elicit presence of attributes that classifies, both practical and verbal skills. (ii) Elicit identification of class of object properties or instances of concepts which			

	are components of definition and showing an instance of their relation to one another, Or identification and classification of concepts from wide range of concepts, e. g shapes, events, sizes (declarative knowledge)			
3. Rule Learning	Teacher's assessment tasks elicit explanation of rules (procedural knowledge)			
4. Higher-ordered Learning	Teacher's assessment tasks elicit transfer performances i.e. applicability of learned skills to new situations, reasoning and problem – solving skills.			

APPENDIX "B"

DOCUMENT ANALYSIS INSTRUMENT

DATE: **LESSON:**

EDUCATOR:

CLASS:

ASSESSMENT TECHNIQUE	**HIERARCHY OF SKILLS**	**SKILLS BEING ASSESSED. (A tick indicates presence)**	**COMMENTS**
Controlled Tests,	Concrete Learning.		
Worksheets/ Class Activities,	Concepts Learning.		
Projects/Assignments	Rule Learning.		
	Problem –solving		

APPENDIX "C"

INTERVIEW SCHEDULE.

A. Educators' biography

1. Tell me about the subject you liked the most while you were at school, and in your tertiary education level?

2. Tell me about your qualifications?

3. Tell me about your experiences in teaching Natural science?

4. What do you think were major strengths in your initial schooling and at your training education level?

5. What can you consider as the major drawbacks in you schooling and training?

B. Perceptions about learning in Natural Science.

6. What do you think is the best way to learn in Natural Science?

7. How would you rank knowledge and skills Natural Science?

8. Are there any levels of doing and thinking in Natural Science?

If so:

(a) Is there any sequential order in which knowledge and skills can be taught?

(a) Can you demonstrate by means of examples the way knowledge and skills can be organised in a sequential order?

9. In terms of 'thinking' and 'doing' are there any levels of thinking and doing in Natural Science?

10. How would you assess these levels of 'doing' and 'thinking'?

11. Is there any sequential order in which these levels of doing and thinking can be organised?

C. Assessment practices in Natural Science.

12. What are the major goals of assessment in Natural science?

13. Do you normally set assessment criteria when assessing your learners?

14. Do you organise the assessment criteria in any order of importance?

15. What kind of questions can you rank as lower ordered questions?

Probe: Give examples of these questions?

16. What kind of questions can you ask to establish that the learner has reached high level of thinking?

Probe: Give one question that will demonstrate this level of thinking?

17. What evidence would you look for, to be sure that the learner is progressing in his/her learning in Natural science?