

**A TEACHING AND LEARNING PROGRAMME TO
ADDRESS LEARNING STYLE DIVERSITY IN THE
NATURAL SCIENCES AT SECONDARY SCHOOL
LEVEL**

RELEBOHILE MAJA

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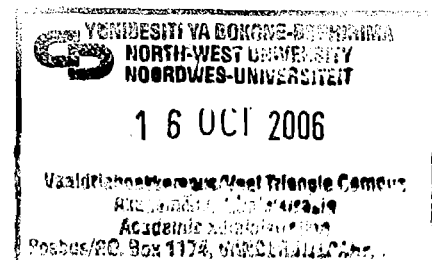
**NORTH-WEST UNIVERSITY
(VAAL TRIANGLE FACULTY)**

PROMOTER: Dr M.M. Grosser

Assistant promoter: Ms H. Meintjes

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DEDICATION

This work is dedicated to my late grandmother, Me Ntsoaki Salmina Monyake, who moulded me; my late mother, Leomile Edith Monyake, whom I never got to know; my brother, S.B.L. Monyake, without whom I would not have been able to read; my loving children Mpho and Thabo, Lebohang and Phumi and my most adorable grandchildren, Atlegang Matona, Lethabo Omphile-Mpho and Gomelemo Reabetswe-Neo; and all my brothers and sisters, nephews and nieces.

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SUMMARY

This study focuses on improving the teaching of the Natural Sciences at the Secondary school level by suggesting that teachers should take cognizance of learners' diverse learning styles when planning for instruction.

Chapter one focuses on expounding upon the problems that are seen as predominant factors in ineffective teaching and learning of the Natural Sciences.

Chapter two elucidates the theoretical framework of the study. Some of the important theories underlying teaching and learning, teaching styles, teaching methods, learning styles and assessment strategies are explored.

Chapter three aims at linking the theoretical framework to teaching in the Natural Sciences. The choice of teaching styles, teaching methods and assessment strategies, particularly in the teaching of the Natural Sciences at secondary school level (Grade nine), are linked with diverse learning styles.

Chapter four outlines the quantitative research design the study adopted. Questionnaires were utilized to determine the perceptions of teachers and learners regarding the extent to which teaching and learning in the Natural Sciences accommodate diverse learning styles.

Chapter five concentrates on analyzing and interpreting the collected data. The data revealed that teachers are finding it problematic, due to a lack of knowledge, skills and support, to plan their teaching so that diverse learning styles are accommodated.

Chapter six focuses on the designed programme in the form of guidelines to assist teachers to address diverse learning styles in the teaching of the Natural Sciences at secondary school level (Grade nine).

Chapter seven concludes the study with a summary as well as recommendations.

OPSOMMING

Hierdie studie fokus op die verbetering van die onderrig in die Natuurwetenskappe vir die Sekondêre skoolfase deur voor te stel dat onderwysers die diverse leerstyle van leerders moet akkommodeer by die beplanning van onderrig.

Hoofstuk een fokus op die verduideliking van probleme wat as die oorheersende faktore vir die oneffektiewe onderrig en leer van die Natuurwetenskappe beskou word.

Hoofstuk twee verhelder die teoretiese raamwerk van die studie. Die belangrikste teorieë onderliggend aan onderrig en leer, onderrigstyle, onderrigmetodes, leerstyle en assesseringstrategieë word verken.

Hoofstuk drie het ten doel om die teoretiese raamwerk in die konteks van onderrig in die Natuurwetenskappe te plaas. Die keuse van onderrigstyle, onderrigmetodes en assesseringstrategieë tydens die onderrig van die Natuurwetenskappe word met diverse leerstyle verbind.

Hoofstuk vier beskryf die kwantitatiewe navorsingsontwerp wat vir die studie gebruik is. Deur middel van vraelyste is onderwysers en leerders se persepsies rakende die mate waarin onderwysers diverse leerstyle tydens die onderrig van die Natuurwetenskappe in die sekondêre skoolfase (Graad nege) aanspreek, vasgestel.

Hoofstuk vyf fokus op die analisering en interpretering van die data. Die data toon aan dat die onderwysers dit as problematies ervaar, as gevolg van 'n gebrek aan kennis, vaardighede en ondersteuning, om onderrig te beplan sodat diverse leerstyle geakkommodeer word.

Die kern van hoofstuk ses is 'n ontwikkelde leerprogram in die vorm van riglyne om onderwysers te ondersteun om onderrig in die Natuurwetenskappe vir die Senior Fase te beplan sodat diverse leerstyle in ag geneem word.

Hoofstuk sewe sluit die studie af met 'n opsomming sowel as aanbevelings.

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CHAPTER ONE

ORIENTATION AND STATEMENT OF THE PROBLEM

1.1 INTRODUCTION

The South African Constitution, Act 108 of 1996, states that no form of unfair discrimination, directly or indirectly, should be practised. Education systems in most countries, especially developing ones, have to a great extent failed to address diverse needs of learners (Engelbrecht, Green, Naicker & Engelbrecht, 1999:14). This oversight results in a great number of dropouts and failures. Informed by these inadequacies to accommodate learners' needs, a movement called The Education for all was launched in Thailand in 1990. Its main concern was to ensure access to basic education for all. South Africa was one of the countries that took part in this launch. The conference concluded that basic education is not simply making schools available to all but also being pro-active in identifying those aspects that might hinder learning (United Nations Educational, Scientific and Cultural Organisation (UNESCO), 1994:5).

The South African government has responded to these demands by phasing in Outcomes-Based Education (OBE) to replace the old system which was not learner-centred. The need for Outcomes-Based Education is brought about by the realisation that not all learners fit into the old system and that most drop out. In the Education White Paper 6 the Department of Education warns that most learners drop out because of failure to identify and accommodate differences, due to instructional methodology breakdown, curricula rigidity and inappropriate learning material (DoE, 2001:24).

Educators also complain that teaching has become more difficult because of the many changes that are taking place in South African education (Woolhauch, 1994:43). It is for this reason that Woolhauch (1994:43) advises that a good Natural Sciences teacher has to be knowledgeable, competent and enthusiastic in terms of content, child development and classroom management.

Outcomes-Based Education requires that, among other things:

- prior learning must be established before the next learning step is taken;
- learners are taught in a way that matches their learning styles;
- learners are allowed to work at their own pace; and
- learners participate in setting learning outcomes and choosing assessment methods (Project People, 1999:11-12).

OBE's most important feature is that conditions and opportunities that enable and encourage all learners to achieve the essential outcomes have to be established within the system (Engelbrecht *et al.*, 1999:21). According to Vos (1995:5), educators have to assist learners to use and understand Science by making it possible for learners to enjoy achievements and learning through self-discovery. Choate (1997:15) and Ogborn, Gunther, Martins and McGillicuddy (1996:116) concur with Vos by insisting that, in order to make it possible for learners to enjoy Science, educators will have to refine existing classroom skills.

The National Curriculum Statement (NCS) which is being phased in to replace Curriculum 2005 places emphasis on the aspect of learners' different learning styles (DoE, 2002). It demands that teachers should vary their teaching styles and methods to suit learners' diverse learning styles. It also instructs educators to plan their assessment accordingly to cater for diverse learning styles.

The complexities involved in modern teaching approaches, as outlined in the preceding paragraphs, have prompted the researcher to undertake a study that will assist teachers to address some of these concerns, specifically to accommodate the diverse learning styles that learners have in any classroom setting.

According to Trojak (1979:4), teaching the Natural Sciences has always been problematic to teachers. Although this statement was made more than two decades ago, the status quo prevails to date, according to the Department of

Education (DoE) (2001:24). A comparison of Grade 12 Physical Science achievements in South Africa with the achievements of those in ten other countries, revealed an average score of merely 325 out of 800 for South African learners, whereas the average score for the majority of learners from the other countries was 500 out of 800 (Howie & Hughes, 1998:4 - 47). Trojak (1979:4), Woolhauch (1994:43), Kramer (1999:12) and Choate (2000:15) highlight the following as causes of this poor academic achievement:

- lack of understanding of the Natural Sciences;
- lack of understanding of how children learn;
- fear of idealizing investigation and exploration during the teaching of the Natural Sciences;
- teachers not taking note of, among others, learning style diversity in classrooms and adapting their teaching according to learner needs;
- curricula rigidity; and
- inappropriate learning material.

In South Africa, this problem is compounded by the fact that most teachers of the Natural Sciences are barely qualified to deal with the demands made concerning the subject matter and instructional methods (DoE, 2001:24). Apart from this, the phasing in of inclusive education in South Africa (see White Paper 6) adds a new dimension to the problem. The South African Constitution, Act 108 of 1996, states that no form of unfair discrimination, directly or indirectly, shall be practised in classrooms any longer (SA, 1996b). The central idea behind this approach is that all learners should be accommodated in main stream education and that the diversity of learning styles should be dealt with in an individualistic approach (Kramer, 1999:10).

The shift from the old paradigm to the new places heavy responsibilities on teachers' shoulders. Lomofsky in Engelbrecht *et al.* (1999:70) feels that teachers, as people who make learning possible, must have positive attitudes, beliefs and feelings towards classroom activities, as these are of crucial

importance. Change is viewed as a threat by some or as an opportunity by others. South African teachers are expected to make major changes in their teaching methods, assessment strategies and attitudes, beliefs and feelings to meet the demands placed upon them by the OBE and the National Curriculum Statement (DoE, 2001:24).

It thus becomes imperative that teachers of the Natural Sciences should adapt to the prevailing education circumstances by looking for alternative methods of classroom instruction which will accommodate the diversity of learner needs, specifically with regard to learners' learning styles.

Gunter, Estes and Schwab (2003:5) state that adapting instructional methods to learning style diversity must be the foundation of all teaching. The more the teachers know about the learning styles of learners, the more they are able to plan a variety of instructional approaches. If teachers of the Natural Sciences fail to accommodate this variety, many learners will be left out of the instructional process and ultimately become unsuccessful in their learning or drop out (Grosser, 2001:16).

Research on learning styles verified quite a number of learning styles (*cf* 2.4). A normal classroom is bound to have learners with a variety of learning styles or combinations of learning styles and thinking modes. Educators who accommodate the diversity of learning styles allow for the same subject matter to be learned in different ways and help balance learners' achievements across different learning preferences (Gunter *et al.*, 2003:5).

1.2 FORMULATION OF THE PROBLEM

Literature highlights the ineffectiveness of teaching and learning in the Natural Sciences which could, among others, be ascribed to the absence of linking teaching intentions and learning outcomes with diverse learning styles in a classroom setting.

The teaching of the Natural Sciences has to be improved to meet the demands made by the changes in the education system such as OBE, inclusive education and the National Curriculum Statement. All of them place

a heavy responsibility regarding effective teaching and learning on the teacher. This study will therefore attempt to address the following questions:

- How well is learning style diversity addressed in the teaching of the Natural Sciences at secondary school level?
- Are teachers skilled well enough to address learning style diversity in the teaching of the Natural Sciences at secondary school level?
- Can teaching and learning guidelines be developed to assist teachers who are teaching the Natural Sciences at secondary school level to address learning style diversity?

1.3 SIGNIFICANCE OF THE RESEARCH

As mentioned earlier, numerous changes are taking place in South African education. The National Curriculum Statement is underpinned by principles that need attention, involvement and the support of all stakeholders. These principles are novel to the entire South African population, especially to teachers. Teachers must receive all the support they require from whatever quarters or source. None of the serving teachers were trained to address the numerous changes. South Africa has just emerged from a segregated fragmented education system into a unified, single system with different new objectives. To put into clear perspective the gravity and magnitude of the paradigm shift, teachers have to make a comparison between the old and the new system as follows:

Table 1.1: Comparison between the old and the new education systems (Engelbrecht, Green, Naicker & Engelbrecht, 1999)

OLD PARADIGM	NEW PARADIGM
Teaching and learning is content/curriculum-based.	Teaching and learning is outcomes-based.
The curriculum instruction and assessment are inflexible.	The curriculum instruction and assessment are flexible.
Time is fixed and controls the system.	Time is flexible i.e. learners learn at their own pace.
Standards are clearly defined and norm-referenced.	There is no sorting or selecting. Learners receive credit for all learning.
Learners are permanently graded.	Learners are defined at their highest level.
Learning breakdown is caused by individual deficit. The learner does not fit into the system.	Learning breakdown is caused by the system, not understanding and meeting learners' needs.
Learning is separated into rigid subjects.	Learning areas overlap and are integrated.
Teaching is teacher-centred. Learning is passive.	Teaching is learner-centred, educators are facilitators and learners are active participants.

The above are some of the giant leaps teachers in general have to make. These are necessary transformations if the education system has to comply with Section 29, paragraph 2(c) of the Constitution (SA, 1996b:14) which says "the education system has the task of addressing the need to redress the results of past racially discriminatory laws and practices."

Principles underpinning the NCS, such as knowledge and skills for all, human rights, inclusivity, socio-economic and environmental justice, articulation and portability, integration and progression, Outcomes-Based approach and credibility, quality, efficiency and relevance, are concepts foreign to many educators.

This study endeavours to assist educators in meeting some of these teaching and learning challenges with relative ease.

1.4 AIMS OF THE STUDY

The overall aim of the study is to improve the effectiveness of teaching and learning of the Natural Sciences in the senior phase by linking teaching intentions with diverse learning styles.

The aim is operationalized as follows:

- to determine how well learning style diversity is addressed in the teaching of the Natural Sciences as secondary school level;
- to determine whether teachers are skilled enough to address learning style diversity in the teaching of the Natural Sciences as secondary school level;
- to develop a programme in the form of guidelines in which teaching intentions and learning outcomes are linked with diverse learning styles.

1.5 RESEARCH DESIGN

This section represents the research design of the study.

1.5.1 Literature study

Both primary and secondary literature sources were studied to gather information on effective teaching and learning of the Natural Sciences. A DIALOG and ERIC database search was conducted with the following key words: Natural Science teaching, effective teaching and learning, inclusion,

teaching styles, teaching methods, learning theories, learning styles, assessment and learner needs.

1.5.2 Empirical study

The empirical study was conducted as follows:

1.5.2.1 Research design

A quantitative research design was utilized to collect numerical data on the analysed ideas and perceptions of teachers and learners (Vermeulen, 1998:13).

1.5.2.2 Population and sample

The research was conducted in the Lejweleputswa District of the Free State province. This district comprises 62 public secondary schools. Ten schools were selected randomly to take part in the research. All the Grade nine learners of the Natural Sciences and their teachers in the selected schools took part in the research. The sample comprised the following :

- Teachers : n = 60
- Learners: n = 711

1.5.2.3 Pilot survey

Before the actual research was conducted, 25 teachers and 50 learners, who were not part of the research group, were identified for a pilot study. The purpose was to check the reliability of the data collection instrument. A Cronbach Alpha coefficient of 0,805 indicated that the data collection instrument complied with reliability criteria (Statistical Consulting Services, 2005).

1.5.2.4 Data collection instrument

- Questionnaires

Information gathered from the literature study was used to develop and design questionnaires to gather information from teachers and learners regarding their perceptions on the effectiveness of addressing learning style diversity in the teaching of the Natural Sciences at secondary school level. The questionnaire comprised structured questions.

The questions aimed at:

- (i) collecting general biographical information;
- (ii) determining the teaching methods and strategies teachers use when teaching the Natural Sciences;
- (iii) establishing the teacher's level of understanding of and adapting teaching to the diverse learning styles;
- (iv) determining the availability of assistance to educators teaching the Natural Sciences in addressing diverse learning styles;
- (v) determining what problems the teachers of the Natural Sciences encounter;
- (vi) determining what problems learners encounter during the teaching of the Natural Sciences; and
- (vii) establishing the academic achievement of learners in the Natural Sciences.

- **A teaching and learning programme**

Based on the findings of the literature study as well as of the empirical study, a programme in the form of guidelines for teaching the Natural Sciences at secondary school level was developed. The programme focuses on linking teaching intentions and learning outcomes with diverse learning styles.

1.5.2.5 Data analysis

Descriptive statistics were used to analyse data. Frequencies, means and percentages were calculated to determine the extent to which the teaching practices of teachers address diverse learning styles.

1.5.2.6 Ethical considerations

The Head of Education in the Free State Province was consulted for permission to conduct the research at the schools (*cf* Addendum C). Teachers of the Natural Sciences, principals, learners and their parents were consulted to explain the study to them and to lobby for their support.

1.6 DEFINITION OF TERMS (ONLY TERMS THAT ARE THE FOCUS OF THE STUDY)

Different researchers use different terms for the same concept or idea. It therefore becomes difficult to give a definition that is not subject to controversy. For the purposes of this research, operational definitions that follow are derived from the South African Department of Education policy documents (DoE, 2002, 2003).

- **Assessment:** a process of gathering information about learners' performance measured against assessment standards of the learning outcomes.
- **Assessment standards:** standards that describe the level at which learners should demonstrate achievement of the learning outcomes and ways of demonstrating achievement.
- **Learning areas:** eight fields of knowledge in the National Curriculum Statements.
- **Learning area statements:** statements for each learning area that set out its learning outcomes and assessment standards.
- **Learning programmes:** programmes of learning activities, including content and teaching methods.

- Outcomes: results at the end of the learning process in Outcomes-Based Education. They help shape the learning process.
- Outcomes-Based Education: a process and achievement-oriented activity-based and learner-centred education process which aims at encouraging lifelong learning.
- Critical/developmental outcomes: the generic, cross-curricular outcomes essential to all educational programmes for all ages. They form the purpose of schooling.
- Learning outcomes: a description of what knowledge, skills and values learners should know and demonstrate at the end of their training. They are derived from critical and developmental outcomes.
- Portfolio: an individual file or folder that contains each learner's work.
- National Curriculum Statement: a curriculum which is introduced to streamline and strengthen Curriculum 2005.
- Teaching style: an overarching characteristic manner or way of presenting learning activities to learners.
- Learning style: the different ways in which individuals approach learning tasks or receive and process information.
- Teaching method: planning teaching in a structured way to achieve a certain outcome.
- Assessment strategy: a tool or an instrument to assess the performance of a learner.

1.7 STRUCTURE OF THE RESEARCH

Chapter 1: Orientation and statement of the problem.

Chapter 2: Addressing diverse learner needs during teaching, learning and assessment.

Chapter 3: Linking teaching, learning and assessment with diverse learning styles in the Natural Sciences.

Chapter 4: Empirical research design.

Chapter 5: Data analysis and interpretation of the results of the empirical study.

Chapter 6: A teaching and learning programme to address learning style diversity in the teaching and learning in the Natural Sciences at secondary school level.

Chapter 7: Summary, findings and recommendations.

1.8 CONCLUSION

This chapter provided a general orientation towards the nature of the problem, significance of the study, aims of the study and its purpose. The next chapter provides an in-depth overview of the theoretical framework for the study.

CHAPTER TWO

ADDRESSING DIVERSE LEARNER NEEDS DURING TEACHING, LEARNING AND ASSESSMENT

2.1 INTRODUCTION

In Chapter one, emphasis was laid on the importance of accommodating the needs of all learners in the teaching and learning environment. This chapter therefore focuses on aspects that are regarded as essential in addressing diverse learner needs. These are:

- the theories underlying teaching and learning;
- teaching styles and teaching methods;
- learning styles; and
- assessment strategies.

These aspects should not to be seen in isolation, but in relation to one another in the teaching and learning environment. Teachers must have a clear understanding of the theories underlying teaching and learning, learners' learning styles and the various methods and strategies for teaching and assessment, in order to plan for teaching and learning where the diverse needs of all learners are to be addressed. It therefore becomes important to define at length the concepts outlined above in order to elucidate and understand the dynamics involved in planning the teaching and learning process. A thorough knowledge of the above concepts will promote effective planning and designing of learning programmes.

2.2 THE THEORIES UNDERLYING TEACHING AND LEARNING

A section on some of the important theories underlying teaching and learning is essential to the study, as the various theories highlight the fact that specific learner needs could be accommodated through the application of a specific

theory in the teaching and learning situation. For the development of a teaching and learning programme it is of utmost importance to take cognizance of the types of learners who are accommodated by the various learning theories. In this way teachers can accommodate the diverse learner needs in the classroom.

Whether or not it is acknowledged or whether there is an awareness of the fact, but parents and teachers each have their personal theory about how learning best takes place (Child, 1995:90). Educators too often employ different teaching methods and strategies in the classroom, some of which are appropriate, but others are not (Child, 1995:91).

To reconcile the relevant psychological issues, psychologists studied the phenomenon "learning" and came up with many theories to explain the processes and principles that underlie learning. No one theory answers all questions about learning (Child, 1995:91), but various theories assist us to develop some understanding of this complex concept. A few of these will be discussed, but first it is necessary to define what a theory is and to determine the role that it plays in teaching and learning.

According to Slavin (1997:13) and Gredler (1992:4) a learning theory is a set of principles and laws that explain broad aspects of learning, behaviour or other areas of interest. It does not help to talk about such a theory without giving ample thought to its practices and implications for teaching and learning. Learning theories are underpinned by the effort to clarify and support classroom practice at any given time. The next few paragraphs intend to examine foundations of learning theories and their praxis, that is, the point where these and the actual practice intersect. A selection of traditional as well as contemporary or modern learning theories will be discussed. All these theories are preferred for the purpose of this study, because each one addresses specific mechanisms that are essential to effective classroom teaching and learning where the diverse needs of all learners are accommodated.

2.2.1 Memory Psychology

Memory Psychology concentrates on the pioneering works of German psychologists Hermann Ebbinghaus (1850-1909) and Ernest Meumann (1862-1915). Remembering is one process that has to occur in order to ascertain that learning has taken place. This implies that learning and remembering cannot be separated. According to the Concised Oxford English Dictionary (COED), remembering means to keep in memory or to bring back into one's thoughts (1990:1016). Human-beings are therefore able to think and reason because they can remember learned facts, and those learned facts are stored in memory (Mwamwenda, 1995:225; Louw & Edwards, 1997:278-308; Kruger & Adams, 2002).

According to Garret, as quoted by Duminy, Steyn, Dreyer, Vos and Peters (1992:225), memory can be classified under fixation, retention, recall and recognition. The authors assert that fixation is concerned with "getting the impression or learning the new activity" (Duminy *et al.*, 1992:225). Retention is a physiological phenomenon, which can only be measured through recall and recognition. The latter two are tools that are used to gauge the permanency of learning (Duminy *et al.*, 1990:225). Recall deals with the reproduction of learned material and recognition involves identification of something that one has experienced before (Mwamwenda, 1995:241). The latter two are measurable and serve to quantify the amount of information actually learned. According to Louw, Botha, Gerdes, Louw, Meyer, Piek, Raubenheimer, Schoeman, Van Ede and Wait (1992:79), memory comprises hypothetical structures and control processes. The three structures, namely the sensory register, the short-term memory (STM) and the long-term memory (LTM) are considered hypothetical because they are not visible structures in the brain or anywhere in the nervous system (Mwamwenda, 1995:243). These control processes that occur within the memory system are not permanent features because they are controlled by an individual person, depending on the task at hand and the previous knowledge and experience relevant to the task (Louw *et al.*, 1992:79). A brief overview of the structures and control processes of the memory system follows.

2.2.1.1 The importance of Memory Psychology for teaching and learning

As Mwamwenda aptly puts it, memory and learning are inseparable. It is the basic duty of teachers to facilitate their learner's memory. This is done so that what is learned and stored can later be retrieved and applied (Mwamwenda, 1995:246). If teachers know how a memory system works and what enhances and retards memory, they are in the best position to assist learners. Duminy *et al.* (1992:228-229) point out that:

- the material presented has an influence on memory (if it is meaningless to the learner it may not be stored in the LTM); and
- learners' characteristics may affect the memorizing of material (age, learning styles, emotions, etc, should be taken serious note of by teachers when memorizing is required).

2.2.1.2 The advantages of Memory Psychology for teaching and learning

Memory Psychology is most useful to teaching and learning, as no learning can be said to have occurred if processes such as fixation, retention, recognition and recall are not evidenced. Memory Psychology equips teachers with skills to develop and improve learners' memories. Thus, a teaching style preferred by learners who prefer learning through sensing and feeling (*cf* 2.4.2). It also draws teachers' attention to those factors that might impact negatively on memory.

2.2.1.3 The disadvantages of Memory Psychology for teaching and learning

As was mentioned earlier, the processes that take place in the memory system and the structure thereof are hypothetical. This might be a disadvantage, because learners who learn only by memorizing might not be able to understand and internalize information and hence not be able to apply what they have memorized.

2.2.2 Behaviourism

Around the beginning of the twentieth century, the Behaviourism theory came into being. Behaviourists only concerned themselves with external behaviour and ruled out internal intellectual experiences and feelings.

Skinner was a Behaviour psychologist who became famous for his experiments on behaviour change in the mid 1930s. He came up with the theory that, if behaviour is rewarded in a manner pleasant to the person who manifested it, that behaviour is likely to be repeated. This was subsequently and appropriately termed Operant Conditioning (Slavin, 1997:154; Child, 1995:96; Gredler, 1992:88-89; Hamachek, 1995:20; Louw & Edwards, 1997:225-256; Kruger & Adams, 2002). Operant Conditioning implies voluntary responses made stronger by reinforcement. Reinforcement in the teaching and learning situation is essential if a desired outcome is to be displayed. This is to encourage the repetition of the behaviour. The reinforcement could be in a form of praise or satisfactory relationships between learners and teachers (Hamachek, 1995:25).

2.2.2.1 The importance of Behaviourism to teaching and learning

There are two important lessons accruing out of this theory to the teacher, as cited by Hamachek (1995:25-26). The one (and most important) is that of reinforcement, and the other is the inherent stimulus potential of the teacher. Reinforcement, especially positive reinforcement, should constantly be used by teachers to cultivate and nurture a desired outcome. The inherent stimulus potential of the teacher plays a role in that it evokes different reactions from learners. The teacher's code of dress, pitch of voice, choice of words, mood, etc. are in themselves stimuli which cause learners to react or behave in various ways.

Duminy *et al.* (1992:237) acknowledge the practical value of this theory by identifying facts that still assist classroom practices. These are:

- Behaviourism made the measurement of objective observable behaviour possible.

- Behaviourism highlighted the fact that children have to be studied differently from adults and that focus should be on their behaviour, actions and reactions.
- Behaviourism contributed to the study and knowledge of infants' emotions.
- Behaviourists' emphasis on conditioning still plays a major role in behaviour modification.
- Laws of learning have made teachers aware that learners can only learn when they are ready to do so.

2.2.2.2 The advantages of Behaviourism for teaching and learning

The Behaviourist theory teaches the importance of motivation and reinforcement. It also makes teachers conscious of the importance of their relationship with learners. As in the case of the Pavlov dog that learned one trick which was later generalized to different situations, the same should apply in the classroom. Teachers are made aware that they should assist learners to apply learned knowledge to different situations (Mwamwenda, 1995:188).

2.2.2.3 The disadvantages of Behaviourism for teaching and learning

Hamachek (1995:243) cites three major disadvantages of the Behaviourist theory of reinforcement. These refer to the fact that extrinsic motivation is over-emphasized; that teachers have too much power and control; and that reinforcement methods produce unpredictable outcomes.

Extrinsic motivation is overemphasized. Using incentives, which are tokens outside the recipient, does reinforce behaviour. When those are removed, the learner is likely not to continue with the desired behaviour (Hamachek, 1995:244).

The teacher may exert too much control. Teachers using reinforcement tend to be central to teaching and learning. They decide what outcomes they require, what behaviour to reinforce in order to achieve those outcomes and

then evaluate how well these preset outcomes are met (Hamachek, 1995:244).

Reinforcement methods produce unpredictable outcomes. Human-beings, unlike other animals, are complex. Their reactions to the environment go beyond conditioned responses because humans have a will; they also have a brain. The will decides in which way they will do something, reinforced or not, and the brain thinks beyond the response into the action itself (Hamachek, 1995:245).

2.2.3 Psychology of Thought

Psychology of thought concerns itself with higher psychic phenomena in human beings such as thinking and actions of the will (Duminy *et al.*, 1992: 250).

The Würzburg School of Psychology under the leadership of Professor Oswald Külpe studied the process of thought by applying the method of experimental introspection. They came up with the following findings:

- In the human mind there are both perceptible and imperceptible images – contrary to the previous notion that the mind is only filled with visible or perceptible images.
- Humans exercise personal awareness in their activities. The “I” plays an important role, unlike in other animals.
- An intentionally directed force directs all mental activities. Thinking is therefore an influence on one’s will. It is “abstract” phenomenon dependent on one’s will (Duminy *et al.*, 1992: 250 –251).

Another school of thought, the Cologne School, suggests that there are three different levels of consciousness through which thinking operates (Duminy *et al.*, 1992:251-254). These levels are:

Lower level of consciousness: This level is believed to contain concrete or perceptible apparatus of thought. It is filled by real or practical experiences which are of sensory and organic origin.

Schematic level of consciousness: The concrete, practical experiences and observations are transformed into schematic shapes of thought at this level.

Abstract level of consciousness: This is the highest level of consciousness, which is the ultimate goal of the process of thinking. It is the purest form of thought (Duminy *et al.*, 1992:251). When thinking occurs at this level, the mind shuttles from this level to a lower level for verification to check whether it is still in touch with reality.

2.2.3.1 The importance of Psychology of Thought for teaching and learning

Important lessons that emanate from this theory are :

- Adults' thinking operates mostly at the highest level of consciousness and that of young children follows the entire route when trying to solve a problem: concrete → schematic → abstract.
- The mentally disabled function at the lower levels, but can gradually develop so that they operate on the higher level, depending on the severity of the disability.

These lessons suggest that teachers should:

- take into account the age of the learners when planning and presenting instructions;
- make sure that the first level is adequately filled with concrete practical observational material, otherwise the two other levels will be incapacitated; and
- not underestimate the power of perception of the external world, especially through the auditory and visual senses.

2.2.3.2 The advantages of Psychology of Thought for teaching and learning

- It makes teachers aware that not all learners operate at the same level of thought.
- It equips teachers with the skills of using audio-visual media, which is so crucial and fundamental to teaching. In this way learners who prefer learning through sensing, feeling and watching (*cf* 2.4.2) are accommodated.

2.2.4 The learning theory of Robert Gagné

Robert Gagné, a psychologist who studied problems surrounding the training of soldiers in World War II, discovered that there are three principles basic to effective and successful instruction. These are, according to Gredler (1992:126), the following:

- providing instruction on a set of components of the entire task, building them towards the completed task;
- making sure that each component presented for learning is mastered before proceeding to the next; and
- presenting the components in a sequence that makes sense in order to acquire optimal and orderly transfer to the final task.

He also believes that learning is assisted by identifying three aspects of learning which are the conditions for learning, the processes of learning and the types of outcomes displayed after learning (Child, 1995:145; Lefrancois, 1997:193-195).

Gagné classifies conditions for learning as external and internal (Gagné, 1977:36). The external conditions refer to a variety of stimuli in one's environment. The internal conditions comprise prior knowledge, relevant and applicable to new information to be presented and to be learned. He

proposes that, for these processes to happen, eight learning events take place. Figure 2.1 explains these events.

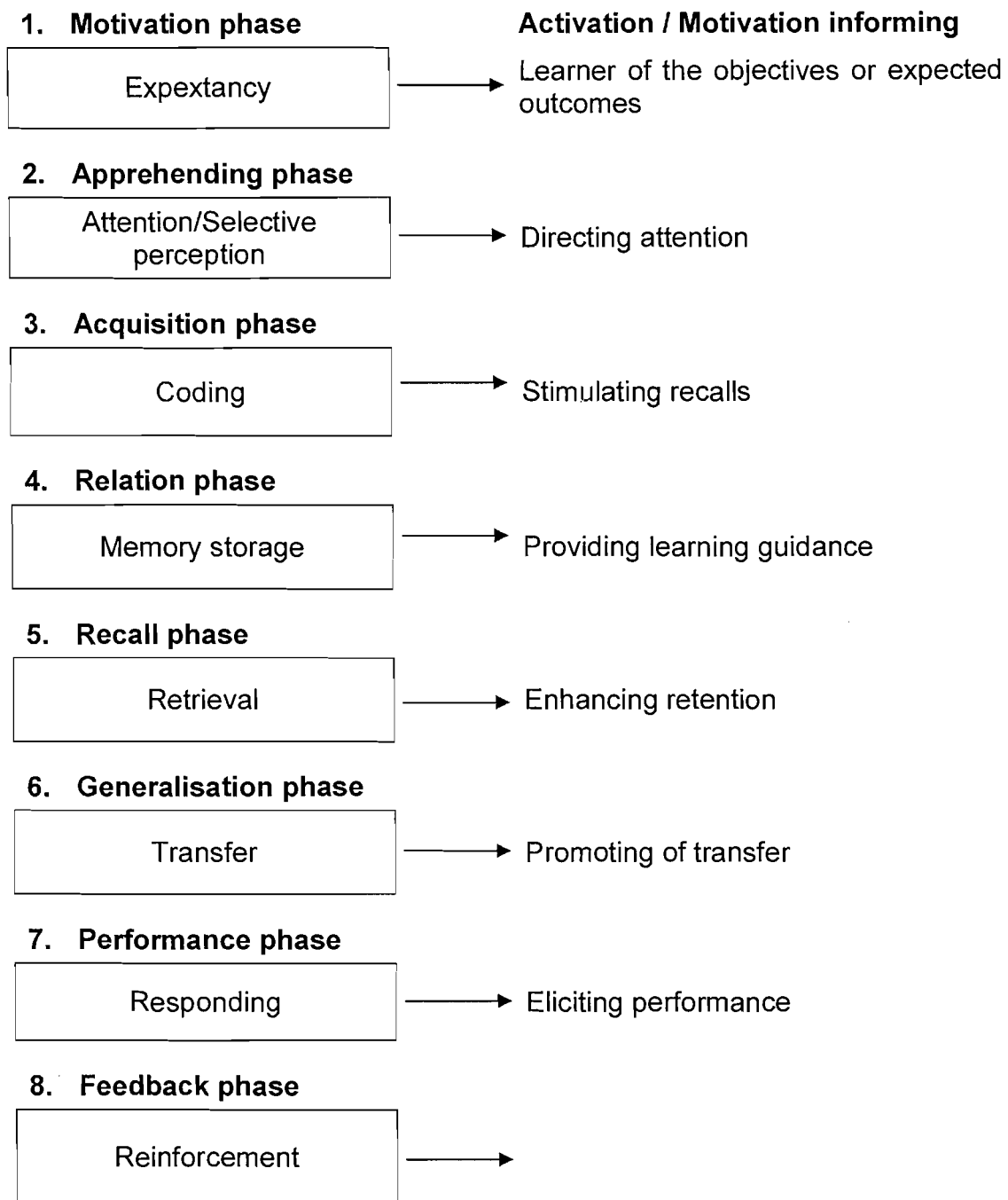


Figure 2.1: Learning events according to Gagné (in Slavin, 1997:233)

The above figure illustrates that the eight phases are events occurring outside the learner (external events). These can be controlled and manipulated by either the teacher or the learner for maximum acquisition of learning. These phases are interdependent and failure of one affects the effectiveness of the

others. Below each phase inside the box, is what Gagné refers to as internal events. The external events are prerequisites to their respective internal events.

It is further suggested that for all these learning events to happen, there are eight corresponding instructional events that the teacher has to implement. These are listed to the right of the learning phases. It is important for teachers to take note of these suggestions if they are serious about the business of teaching and hence, of learning.

The importance of this theory for teaching and learning lies in the fact that diverse learners are accommodated through the eight learning events. Perception involves the senses (sensors and feelers) (*cf* 2.4.2), coding involves reflective observation (watchers) (*cf* 2.4.2) and transfer involves thinking and doing (thinkers and doers) (*cf* 2.4.2).

2.2.5 Cognitive learning psychology

2.2.5.1 Jean Piaget

Jean Piaget, a Swiss biologist-psychologist, formulated theoretical conclusions based on his study of children's intellectual development. His point of departure is that a child's intelligence develops in a definite sequence at definite stages. Although the stages might overlap, each of the stages is characterized by identifiable ways of thinking which are specific to that stage (Hamachek, 1995:147; Louw & Edwards, 1997:472). He does not view knowledge as a product of something, but as an ever-changing process (Gredler, 1992:216).

His studies led to an analysis of cognitive development that describes basic physical, logical, mathematical and moral concepts from birth to adolescence (Child, 1995:157). Piaget maintains that intelligence is dynamic and cannot be quantitatively assessed. It is a way by which an individual interacts with the environment (Gredler, 1992:221).

Piaget's explanation of cognitive development is based on the assumption that human-beings are in continuous interaction with their environments (Slavin, 1997:32). He believed that all human beings have innate capabilities to interact with their environments in order to make sense of what surrounds them. He refers to these capabilities as schemes (Slavin, 1997:32). He defines schemes as mental patterns that guide behaviour. Children (and adults) use these schemes to construct and revise their sense of reality constantly and continuously. During this process, the schemes become more organized and adaptive. It is his postulate that these basic tendencies of organization and adaptation are inherent to human nature (Biehler & Snowman, 1986:58).

Organization implies human tendencies to continue processes into meaningful coherent systems (Biehler & Snowman, 1986:58). Adaptation refers to the human tendency to adjust to the environment. According to Piaget, this is done by means of two fundamental processes, namely **assimilation** and **accommodation**. The former is the integration of new information into existing schemes. The latter implies adjustment of the existing cognitive structures as schemes in order to accept new information (Slavin, 1997:33; Child, 1995:158; Gredler, 1992:223; Hamachek, 1995:148; Louw & Edwards, 1997:387).

According to all the authors cited above, equilibrium occurs when accommodation and assimilation strike a balance.

Piaget's theory is **genetic** (higher-order processes evolve from biological mechanisms i.e. development of one's nervous system), **maturational** (concept formation follows a distinct pattern of clearly definable stages at specific age groups) and **hierarchical** (all the four stages must be experienced in a given sequences). Piaget identifies four consecutive cognitive developmental stages

- **Sensorimotor (0 - 2 yrs)**

At this stage, children develop schemes through sensory impressions and motor activities. Action schemes are developed here.

- **Pre-operational (2/3 yrs - 7/8 yrs)**

Children develop the ability to use symbols to represent objects. This is the beginning of logical thinking. Thought processes are still based on perceptual cues and are not capable of reversing actions mentally.

- **Concrete operational (7/8 yrs - 11/12 yrs)**

Thinking is limited to concrete, observable objects that are actually present. Children are inquisitive about why things happen the way they do. Their thinking is based more on logical reasoning than on intuition.

- **Formal operational (11/12 yrs)**

At this stage, children are able to form and test hypotheses, solve problems systematically and use higher-order learning skills, etc.

The age group that this study is focusing on is 14 years and above. It makes sense, therefore, to single out the last stage of cognitive development and examine how knowledge of Piaget's theory can assist the teacher. Attention is drawn to the fact that these years are guidelines to mental milestones expected of children at that age.

As mentioned earlier, these changes from one stage to another are gradual. Teachers are advised to take notice of this fact during the planning of learning experiences. Gredler (1992:297-298) interprets this notion in the form of a spiral and not of arrows. This is to show that it is one continuous spiral with no clear lines of demarcation between stages. As teachers plan learning experiences, the knowledge of their learners' mental age will guide them in the choice of content, methods, learning material, activities and assessment methods.

2.2.5.2 Lev Vygotsky

This theory is based on the premise that a human being's mental activities are the result of cultural learning, using social signs (Child, 1993:171, Kozulin,

Ageyev & Miller, 2003). Vygotsky believes that human mental abilities are developed through social interactions and experiences (Gredler, 1992:265).

In contrast to Piaget's suggestion that development precedes learning, Vygotsky argues that learning precedes development. Vygotsky posits that for mental development to occur a child should have acquired knowledge of signs through interacting with his/her surroundings (Slavin, 1997:46). If the child is able to use these signs to think and solve problems without the assistance of others, then development has occurred. This process is referred to as self-regulation (Slavin, 1997:46).

Although Vygotsky believes that learning leads to mental development, he classifies learning into two types, namely spontaneous and scientific concept formation (Fosnot, 1996:18). Spontaneous concepts are those developed naturally through the child's own daily interaction with his/her environment, while scientific concepts are more formally and more logically defined, and originate in formal classroom activities (Fosnot, 1996:18). He believes that cognitive development requires mastery of cultural communication systems first, and then learning to use them for one's mental processes (Slavin, 1997:47).

According to Vygotsky, cognitive development occurs during the period when the children are situated mentally between tasks they can do independently and those that they could do with the assistance of competent adults or peers. He refers to this period as the zone of proximal development (ZPD) (Pressley & McCormick 1995:181; Kozulin *et al.*, 2003). This is defined as behaviour beyond a child's level of autonomous functioning, but within reach with assistance and, as such, reflects behaviours that are developing (Pressley & McCormick 1995:181).

It is Vygotsky who suggested that learning occurs best when it is done within one's zone of proximal development. It is at this stage that assistance and support of teachers and expert peers is sought, but gradually diminishes until complete responsibility is left to the learners (Pressley & McCormick, 1995:182).

Knowledge of where the child's zone of proximal development is, is useful to teachers because this gives an indication of what the child can do independently or with assistance. The teacher's planning for learning experiences should take cognizance of this fact so that tasks and activities given to learners should be within their zone of proximal development (Pressley & McCormick, 1995:181, Kozulin *et al.*, 2003).

Social learning is a theory that was propagated by Vygotsky and has been used in classroom instructional methods such as co-operative learning, projects, group discussions and discovery. According to Vygotsky, talking about a problem aids thinking, and hence problem-solving. During group discussion, learners hear each other thinking and thus learn how to go about solving problems. It is believed that successful problem-solvers talk through difficult problems (Pressley & McCormick, 1995:182).

Vygotsky also emphasizes the idea of **Cognitive Apprenticeship**. This is a combination of the social learning and the ZPD concepts. It refers to a situation where a learner acquires knowledge through interaction with experts either in the form of a teacher or a more advanced learner. These experts 'model' what is to be learned and gradually initiate or socialize the novice learner into the tasks to be learned. By using more advanced learners in groups during co-operative learning, this concept is applied (Pressley & McCormick, 1995:183).

Mediated learning is also promoted by Vygotsky. This means that learners should be given complex, difficult, but realistic tasks. They should then be shown enough support to carry them out, rather than to be given small bits of a task and to put these bits together later to form the whole. When learners are assigned projects, asked to role-play or explore the environment, told to write an essay to be presented to real audiences, this principle is applied.

2.2.5.3 Jerome Bruner

Bruner formulated a theory of which the point of departure is that learning occurs through systematic, structured learner experiences via a spiral curriculum (Capel, Leask & Turner, 2003:241). He also emphasizes active

restructuring of knowledge through experience with the environment. He believes that learners should organize their own knowledge using methods such as discovery, especially guided discovery (Child, 1995:119). He describes learning as information-processing activities by which learners simplify and make sense of the environment (Lefrancois, 1997:202).

Like Piaget, Bruner posits that cognitive development occurs in stages. He gives three developmental stages, namely:

- **The enactive stage:** where learning occurs through the physical manipulation of objects. (This compares with Piaget's sensory-motor stage.)
- **The iconic stage:** where learners rely on visual representations of information for their learning. Their visual perceptions determine their interpretation of the world around them. (This compares with Piaget's pre-operational stage.)
- **The symbolic stage:** where learners understand symbols, scientific notations and figures. It is at this stage that learners are capable of absorbing great quantities of information of varying types. (This compares with Piaget's concrete and formal operation stages.)

Bruner advocates the use of the following concepts in learning:

- **Discovery learning:** As mentioned earlier, Bruner believes that learners learn best by using the discovery method. They need to experience understanding something through their own active methods, such as intelligent guessing and inductive reasoning.
- **The spiral curriculum:** This means that learners revert to what they have already learned as they progress with studying new material.
- **Active learning:** Learners have to be motivated to explore. The use of extrinsic motivation such as rewards could be employed at the introduction of a new concept. Learners should later evoke their own innate curiosity and desire to explore.

Teachers are called upon to encourage learners to discover rules, laws and principles by themselves, as this is more meaningful to them. They own the knowledge if they unearth it themselves.

2.2.5.4 Ausubel

Ausubel, an American educational psychologist, directed his study at the child's learning activities in the classroom (Duminy *et al.*, 1992:274). He believes very strongly that the psychology of learning revolves around this single factor that learning is influenced by what is already known by the learner (Mwamwenda, 1995:216) .

Since Ausubel's focus was on learning as it occurs in the classroom setting, he concentrated on trying to understand the essentials of learning and came up with two dimensions of learning which he identifies as how one learns and how one integrates new knowledge. In studying these two dimensions, he concludes the following (Duminy *et al.*, 1992:274).

Dimension 1 – How does one learn?

This dimension comprises two forms of learning, namely reception learning and discovery learning.

Reception learning: Learners are presented with complete information in the form of a lecture, picture, audio tapes, etc. (Mwamwenda, 1995: 216; (Duminy, 1992:275).

Discovery learning: Learners discover information and knowledge for themselves. The teacher's role is to create opportunities conducive to this type of learning and provide guidance, i.e. facilitate learning (Duminy *et al.*, 1992; Mwamwenda, 1995:214).

Dimension 2 - How does one integrate new knowledge?

This is made up of two methods or ways by means of which new knowledge is integrated into existing schemes, namely through meaningful learning and rote learning.

Meaningful learning: According to Ausubel, learning material is only potentially meaningful. It acquires meaning after the learner has made meaning out of it (Duminy, 1992:276; Mwamwenda 1995:48). Learning, writes Mwamwenda, can only be meaningful if it relates to what the learner already knows (Mwamwenda, 1995:218). Integration of new material into cognitive structures occurs through meaningful learning (Duminy *et al.*, 1992: 276) .

Rote learning: This takes place where memorization is done without any serious attempt to understand what is being learned (Mwamwenda, 1995:218). Rote learning involves committing learning material into memory *verbatim*.

Ausubel believes that learning can be improved through assimilation and advanced organizers:

- **Assimilation** is a process through which new information is linked to already existing cognitive structures (Duminy *et al.*, 1992:216).
- **Advanced Organizers** is a technique used to bridge the gap between learned material and new learned material. Ausubel believes that learners use learned material as the frame of reference for mentally organizing and re-organizing new material. Teachers therefore have to provide a broad outline of what is to be taught in the form of illustrations, pictures, comparisons, contrasts and verbal metaphors (Mwamwenda, 1995:218; Duminy *et al.*, 1995:278).

2.2.5.5 The importance of Cognitive Psychology for teaching and learning

Cognitive learning psychology forms the basis from which knowledge of teaching occurs.

- It makes teachers aware that cognitive development occurs in stages, and that different people develop at different rates, although there is a norm.

- It makes teachers realize that other factors such as culture, biological growth, environment, socio-economic conditions have a direct impact on cognition.
- It draws the teachers' attention to the fact that cognitive development, is partly a result of maturation and partly a result of what is learned from life experiences (Kruger & Adams 2002:32).

2.2.6 The alternative Constructivist Approach

This approach stems from the theories of Piaget, Bruner, Ausubel and Vygotsky' as discussed in the previous paragraphs of this chapter (*cf* 2.2.5).

Constructivists use, as their point of departure, the concept that learners actively construct knowledge and strategies used to acquire knowledge (Child, 1995:167; Prawat, 1992:360).

Prawat (1992:354-380), Capel *et al.* (1995:222) and the Free State Department of Education (2004b:8) indicate that Constructivism is founded on the following basic principles:

- Learning is a search for meaning. Learning should therefore be based on issues that call for personal interpretations.
- Construction of meaning requires a comprehension of the whole picture, as well as parts of the whole.
- Application of knowledge is a primary emphasis.
- Learners are seen as purposeful and responsible for their own learning and not passive recipients of facts. They bring their own experiences and prior knowledge to a teaching and learning situation.
- Learning is an active process which involves construction of meaning and takes place through interpersonal negotiation.
- Knowledge is personally and socially constructed and not something sitting out there to be grabbed.

- Teachers/learners bring their prior conceptions to a learning/teaching situation.
- Teaching is not mere transmission of knowledge, but organizing of classroom situations and designing of tasks in a manner that promotes effective learning.
- The curriculum is viewed as a programme of learning tasks and not as something to be learnt. It is a source of material from which learners construct knowledge.

According to Fosnot (1996:24), an individual's cognitive structure cannot be understood unless that individual is observed interacting with others in context within a society. This author posits that learning is a case of self-organization and internal restructuring.

Slavin (1997:270-273) outlines the following as foundations of Constructivism: the Constructivist Approach confronts learners with a problem and then gives guidance on how to go about finding solutions. It encourages learners to brainstorm, explore, experiment and interact, until they come up with a solution.

The Constructivist Approach uses the co-operative learning method extensively. This method is preferred because it is believed that learners discover and comprehend complex concepts when they talk among themselves. It is another way of evoking the social-learning and group/peer-teaching promulgated by Vygotsky (Slavin, 1997:271).

The Constructivist Approach stems from the premise that all learning is discovered. If learners are supplied with new information, they have to interact with it mentally until they make it their own. Learners are encouraged to learn on their own through active involvement with concepts, principles, laws and theories. They conduct experiments to validate these principles or to rediscover them and reformulate them to suit their own cognitive structures (Slavin, 1997:273).

Basing teaching and learning on this approach will accommodate learners who favour thinking and action during learning (*cf* 2.4.2).

2.3 TEACHING STYLES AND TEACHING METHODS

2.3.1 Teaching styles

Within each of the aforementioned approaches to teaching, teachers can utilize a variety of teaching styles. Teaching styles refer to the overarching characteristics, manner or way of presenting learning activities to learners (Grosser, 2001:4, 21). This term is used to describe how a learning experience is conducted (Capel *et al.*, 2003:245). Defining a teaching style is almost impossible because teachers tend to use different teaching styles in the teaching and learning situation (Capel *et al.*, 2003:246). However, there are descriptors to identify different ways of teaching. Words such as experiential, progressive, content-based, process-based, etc. are often used to give an indication of the way a teacher might conduct a specific lesson.

There are two major teaching styles, namely the ***transmission-reception style*** and the ***facilitation style*** (Kramer, 1999: 12).

2.3.1.1 The transmission-reception style

The transmission-reception style is characterized by the teacher who takes a central role in the teaching and learning process and is in command of the teaching and learning process. It is a closed style, where formal teaching and little learner participation takes place (Capel *et al.*, 2003:254). The teacher becomes the source of knowledge and learning, as highlighted in the learning theory of Memory Psychology (*cf* 2.2.1).

2.3.1.2 The facilitation style

The facilitation style is characterized by the learner taking a central role in the learning process and the teacher acting as a facilitator. This style allows for a high degree of learner involvement and personal inquiry (Kramer, 1999:10; Vermeulen, 2000:13). Capel *et al.* (2003:250) refer to this style as “framed”. The lesson” structure is presented and learners make inputs and

interpretations. Learners play a major role in directing the lesson, whereas teachers provide guidance. Clearly a style underpinned by the Constructivist learning theory (*cf* 2.2.6). Finer distinctions of this style include the following.

- **The practical style:** Learners make decisions and there are practical group tasks which allow the teacher time to attend to individual learners.
- **The reciprocal style:** Learners are paired. Each partner is actually involved in the task. There is natural evaluation of performance by learners.
- **The self-check style:** Teachers set tasks and learners evaluate themselves against the set criteria and determine their own new goals in conjunction with the teacher.
- **The inclusion style:** Teachers set different tasks to accommodate learners with different learning capabilities so that they all experience success.
- **The guided discovery style:** Learning programmes are planned according to learners' cognitive development. Teachers then guide learners towards the desired outcome
- **The divergent style:** Teachers encourage learners to find multiple solutions to one problem.
- **The individual programme learners' design:** Learners design and implement their programme within guidelines agreed upon and monitored by the teacher.
- **Learners' initiated styles:** Learners are stimulated to work and learn. The teacher assumes a supportive role and learners work on areas of own interest.
- **The self-teaching style:** As the name implies, this is teaching oneself from own experience. Teaching and learning occurs without external support.

All these teaching styles comply with the dictates and specifications of Outcomes-Based Education and the National Curriculum Statement. None of them should thus be employed at the expense of others.

According to Capel *et al.* (2003:246-252), the choice of a particular teaching style is influenced by three major factors:

- **Teachers' professional knowledge.** This means that, if teachers are ignorant of teaching and learning theories, their choice of an appropriate teaching style could be hampered. Teachers' classroom management skills have an influence on their teaching styles. Content knowledge and competency affect teachers' behaviour and subsequently their choice of teaching styles.
- **Teaching environment.** Factors such as the physical and mental state of learners, departmental policies of streaming and grouping learners, shortage of resources and class size are often linked to the choice of teaching styles. For instance, teaching a group of 60 demotivated learners will not be the same as teaching the same number of positively motivated learners. It is therefore necessary that the teachers' choice of teaching style should differ accordingly.
- **Teachers' personal qualities.** Each individual has personal qualities and characteristics. Qualities such as pitch of voice, body language, confidence, competency, enthusiasm, compassion, ability to form positive relationships with learners, stereotype, prejudices, openness, etc. influence one's teaching styles.

2.3.2 Teaching methods

Within each teaching style, teachers can utilize a variety of teaching methods. Teaching methods, according to Jacobs, Gawe and Vakalisa (2004:175), are particular techniques that teachers use to help learners gain the knowledge which they need in order to achieve a desired outcome.

A teaching method refers to a range of teaching strategies or techniques chosen for lesson instruction purposes (Capel *et al.*, 2003:246). The authors maintain that a teacher could use more than one teaching method and teaching style in one lesson

Fraser (1992:139) defines a teaching method as a procedure desired to achieve a specific objective. This author further states that a variety of activities and teaching methods could be utilized to present one concept or unit to accommodate a diversity of learners, as Outcomes-Based Education demands. The teacher needs a well thought out and well planned procedure to guide learners to reach desired outcomes. It is suggested and strongly encouraged that teachers should be flexible in their teaching methods because different teaching methods are appropriate for addressing different situations.

Teaching methods should not be randomly selected, but have to be guided by factors such as learners' age, cognitive development, learning styles, learning outcomes, learners' beliefs and values, learning area and learning content (Jacobs *et al.*, 2004:176). A teaching method is a way of sensing, thinking, and feeling and of being a design embodied in action (Quina, 1989:140; Killen, 1998:11; Jacobs *et al.*, 2004:195).

The following diagram is an expose of how teaching styles link up with teaching methods, as discussed by Grosser (2001:4). Time is devoted to this section because it is deemed essential and relevant to this study to discuss teaching methods in order to make it easier to refer to them when later dealing with the designing of the programme.

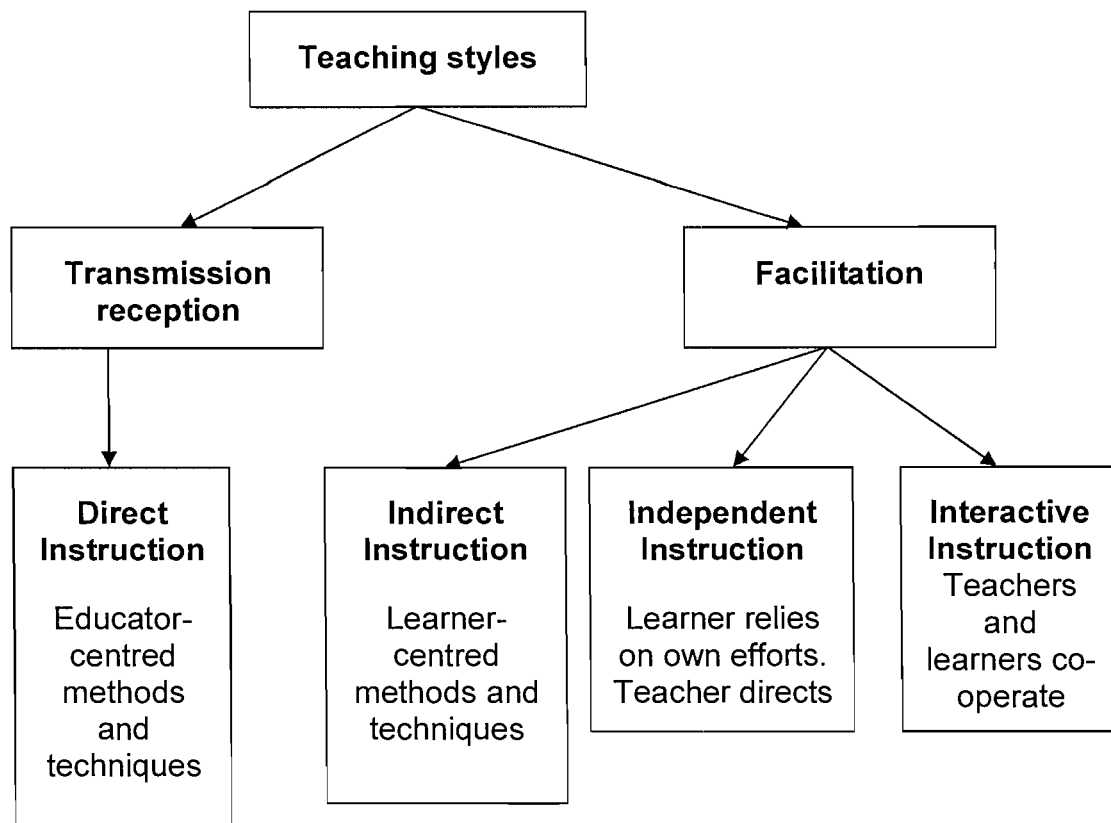


Figure 2.2: An overview of teaching styles and methods

The figure above indicates four distinct teaching methods and their connection to specific teaching style. Each method implies a specific approach to teaching, learning and assessment, as discussed below.

2.3.2.1 Direct Instruction

This method is teacher-centred; the teacher delivers content and directs all learner activities, while the teacher makes statements of fact and gives examples to validate the facts. Clearly a method underpinned by the learning theory of Memory Psychology (*cf* 2.2.1). Although OBE stresses that teaching should be learner-centred, this method should not be seen as useless and ineffective. Teachers are still in control of the content, hence responsible, but they are cautioned to use this method sparingly for the attainment of certain outcomes, i.e. explaining concepts (Jacobs *et al.*, 2004:175). This method is useful for presenting information, facts, concepts and new ideas, in other words: to teach cognitive outcomes related to recall

and the recognition of facts. It is, however, not useful for building skills or understanding.

Direct Instruction does not refer to the teacher merely lecturing a group of learners. It includes a variety of techniques:

Table 2.1 Techniques for Direct Instruction

TECHNIQUE	APPLICATION
Lecture	Teacher presents talk with visual aids. Learners take notes.
Dictation	Teacher reads or speaks. Learners write exactly what is said.
Presentation	Teacher leads discussion with oral presentation.
Drill and practice	Teacher presents examples. Learners then do problem-solving.
Guided worksheets with corrective feedback	Teacher guides, class works through work sheets step by step.
Video, film, tape, radio presentations	Class views presentation, taking notes.
Didactic questioning	Teacher leads learners by using questions, moving from lower to higher-order questions.
Demonstration	Teacher shows or illustrates skill or principles.
Guided writing, reading or listening	Teacher uses structured format to lead learners towards specific learning outcomes.
Team teaching	Teachers work together to illustrate debates, different perspectives or approaches to learners.
Visitor presentation	Presentations by visitors, community, parents, ex-learners from school, etc.

According to Killen (1998:4), the direct teaching method has the following advantages for teaching and learning:

- The major advantage is that of giving the teacher full control of the learning content.
- It is an effective way of imparting factual knowledge to low-achievers.
- Much information can be given in a short time.
- It is equally effective in large or small classes.
- Teachers are able to emphasize important points and possible difficulties.
- It enables teachers to stimulate learners' interest by displaying their personal interest of the subject.
- A non-threatening environment for learners is created, learners are not forced to be active participants and this avoids embarrassment as they do not display their ignorance or shyness.

Killen (1998:5-6) also indicates disadvantages of the direct teaching method:

- This method assumes that learners are able to assimilate information through listening, observing and note-taking.
- It does not care for diversity of learners, their prior knowledge, learning pace, cognition level, learning styles or learners' interest in the subject matter.
- It does not foster social and interpersonal skills development due to its limited learner activity.
- Its success depends heavily on the image the teacher portrays.
- It may have a negative impact on the learners' skills such as problem-solving, creativity, explanation and enquiry.
- It limits learners' opportunities when the learning material is complex.

- It presents learners with teachers' views and how to organize content.
- It does not often hold learners' attention span for more than fifteen minutes.
- It gives learners an impression that they have to be told what to do by the teacher at all time.
- It limits learners' feedback to teachers concerning their level of understanding.
- During a demonstration lesson, learners may not see what the teacher wants them to see.

Clearly this method has more disadvantages than advantages. Petty (1995:108) advises that this method should not form more than 60% of teaching. Good teachers know when to shut up.

Direct instruction methods are an important and a vital component of all teaching and learning, but, as with all things, it should be one part of the overall approach to teaching, rather than the only approach (Grosser, 2001:23). The discussion indicates that only certain learners are accommodated when this method is utilized most of the time, namely seniors and feelers and watchers (*cf* 2.4.2).

2.3.2.2 Indirect Instruction

Indirect Instruction is characterized by a high degree of learner involvement. Learners are actively involved in constructing their own knowledge. Clearly a method underpinned by the Constructivist and Cognitive learning theories (*cf* 2.2.5, 2.2.6). This method holds a high potential for building higher-order thinking skills, personal values and individual responsibility for learning. It is not effective for learning facts, complex concepts, principles or processes that need step-by-step understanding. It includes the following techniques:

Table 2.2 Techniques for Indirect Instruction (Grosser, 2001:26,27)

TECHNIQUE	APPLICATION
Oral presentation	Learners prepare a fixed time presentation for class.
Concept maps	Learners create topic-based mind maps.
Case studies	Learners study a given real or fictitious situation in order to understand concepts, facts and principles.
Delivering lessons	Learners act as teachers in planning and delivering a lesson.
Theme posters and collages	Learners create an educational poster or collage to illustrate issues relating to the topic.
Role play and simulations	Learners prepare and simulate situations and characters.
Design-and-make activities	Learners plan and construct products or performances.
Group projects	Groups of learners collaborate on various projects.
Field trips and site visits	Visits to authentic sites are used as a basis for learning topics and themes from the curriculum.
Investigations and experiments	Learners undertake discipline-based procedures to learn principles and concepts.
Debates	Learners research and build logical arguments to support a particular perspective in a debate.
Interviews	Learners have the task of gathering data from other people and specialists on various topics.
Surveys or drawing conclusions	Learners gather data about topics in order to make predictions and conclusions.

Advantages of Indirect Instruction:

- There is a high degree of learner involvement.
- Learners are active participants and teachers facilitate.
- It has a high potential for higher-order thinking skills development.
- Information is provided by the teacher as another source.
- It encourages personal enquiry.

Disadvantages of Indirect Instruction:

- It can be time-consuming.
- It is challenging to teachers who are comfortable with full control of the class (authoritarianism).
- It is not very effective for learning facts, principles or concepts step-by-step.

2.3.2.3 Independent Instruction

According to this method of instruction, a learner undertakes a learning task by him/herself. The learner relies on his/her own efforts and thinks through every aspect of the task without constant and close management by the teacher. The teacher's role is merely to direct and help. It includes the following techniques:

Table 2.3: Techniques for Independent Instruction (Grosser, 2001:36)

TECHNIQUE	APPLICATION
Homework	Work outside regular class or school time.
Research projects	Information on a topic is collected, collated and presented independently for analysis in class.
Report projects	Projects done completely outside class: includes purpose, definition of terms, data, analysis, references.
Interview tasks	Learners identify and conduct interviews with role models and present results in class.
Assigned questions	Teacher prepares questions that learner works through. This is used to recall prior learning or to reinforce new learning.
Equipment-assisted learning	Learners use computers, scientific or other equipment for learning. This ensures individual practice of skills.
One-on-one debates	Learners prepare own notes before discussing with a partner.
Learning centres	Special space created in the classroom for learners to find and use resources for special tasks.
Writing assignments	Essays, paragraphs or sentences done individually.
Self assessment	Learners assess themselves and their own work, using various techniques, guided by the teacher.
Worksheets	Learners themselves work at their own pace.
Crossword puzzles	Teachers prepare crossword puzzles for learners to complete by means of research from books or notes.

Other techniques for independent instruction refer to the following:

2.3.2.3.1 Discussion

This is a discourse between two or more people with a definite view in place (Jacobs *et al.*, 2004:176). It is an orderly process of face-to-face interaction in which people exchange ideas for the purpose of solving a problem (Killen, 1998:27). It involves fairly-free conversation which gives learners an opportunity to exchange their views freely (Petty, 1995:159).

2.3.2.3.2 Problem-solving

This method, sometimes referred to as the heuristic method, allows learners to discuss things on their own and practise to solve problems (Jacobs *et al.*, 2004:199). It inspires learners towards meaningful learning (Avenant, 1990:279) and it is a form of inquiry-learning (Killen, 1998:106).

This method can be most effective if the problems are real and challenging to the learners (Jacobs *et al.*, 2004:200). The complexity of the problems should be in accordance with the learners' cognitive level.

2.3.2.3.3 Questioning

This is a most, basic but key technique in a teaching-learning situation. Questioning is a technique that can be used to link previous knowledge to new information (Jacobs *et al.*, 2004:188). It is used to direct the focus and attention of learners to the point at issue. It is used to arouse learners' interest and stimulate their thinking. It can also be used to probe learning (Slavin, 1997:244).

This technique is very taxing, mentally, to both teachers and learners. Teachers have to prepare thoroughly and should at all times be alert because answers supplied by learners are often unexpected and unpredictable.

Teachers have to know the types of questions to be asked to achieve the purpose they envisage. On the other hand, learners have to be alert and attentive in order to understand and interpret the question properly. This

method can be used effectively to enhance learners, reasoning and thinking skills if open-ended questions are used.

Capel *et al.* (2003:85) warn that questioning requires teachers to be able to ask clear appropriate questions, to use pause to allow learners to think about an answer before responding, to prompt to help learners with problems, to use follow-up questions to probe further, to encourage learners to develop their answers, to extend their thinking, to change the direction of questioning to include the entire class.

Questions are used to guide learners to discover new ideas for themselves. The way questions are asked can make learning more interesting or fail to inspire learning (Steyn, Badenhorst & Yule, 1991:44). Teachers are therefore advised to perfect their questioning skills before applying this method. Questions should be asked for the following reasons:

- to promote intellectual activity;
- to involve learners as partners in the teaching and learning situation;
- to motivate learners by drawing their attention to something; and
- to obtain feedback about learners' abilities to understand, remember, apply knowledge, as well as about their level of learning-area knowledge (Steyn *et al.*, 1991:44).

To achieve the four objectives above, teachers should direct their questions at the appropriate cognitive level of learners. Questions should therefore be in accordance with the three identified types:

- Lower-order questions. According to Steyn *et al.* (1991:44) these questions require more recall of existing knowledge.
- Middle-order questions. These require learners to apply existing knowledge to new situations.

- Higher-order questions. These require learners to interpret, analyze, predict, apply, hypothesize synthesize, and evaluate (Steyn *et al.*, 1991:95; Ayerst, van der Schyff, van Rensburg & Roux, 1998:21).

Questioning has the following advantages:

- Questioning facilitates active participation and spontaneous learning by learners;
- Questioning ensures that no learners are left behind;
- Questioning assists teachers in clearing any myths and misinterpretation of knowledge by learners; and
- Questioning directs learners' focus to those concepts, which need emphasis (Jacobs *et al.*, 2004:188).

2.3.2.3.4 The project method

In this method, learners participate in a project which is either designed by the teacher or by learners themselves (Jacobs *et al.*, 2004:196). It is a method based on purposeful activities of learners which have to flow from learners' natural interest in a task which can be a problem in their daily lives (Steyn *et al.*, 1991:34). In this method, teachers give more purposeful guidance in that they provide learners with the method to follow and sources to consult (Avevant, 1990:289). Learners investigate different aspects of a problem individually and put their findings together to form one solution to the problem.

For this method to succeed there must always be a clearly outlined problem which must lead to a problem-solving activity (Steyn *et al.*, 1991:35). The teacher must give precise unambiguous instructions about what and how things should be done, availability and location of resources and the length of time to be taken on the project (Jacobs *et al.*, 2004:196).

The project method has the following advantages:

- Work is not forced onto learners but accepted as worth while.

- Healthy social attitudes are cultivated through working together
- It is useful for large classes because learners can be divided into smaller working groups.
- It allows learners to work on different projects at the same time. That is, the teacher can allocate as many projects as reasonable to the same number of groups and later each learner will learn from other group's presentations.
- Many themes can be covered by one project (Steyn *et al.*, 1991:36).

2.3.2.3.5 The experimental method

This method is generally used in the Natural Sciences. It allows learners to discover reality and thus verify specific rules and laws that have been researched and proven (Jacobs *et al.*, 2004:200). It is a method that offers active learning and achievable challenges that motivate learners and engage their interest (Petty, 1995:222).

For this method to be successful, Petty (1995:222) suggests that the following should happen:

- Learners must have essential background knowledge and the necessary skills to conduct the experiment.
- Learners must understand precisely what they have to do
- Most learners must be able to perform the task assigned to them. Teachers have to know their learners, capabilities' before giving them any task.

The experimental method has the following advantages:

- It is effective for developing learners' understanding.
- It motivates all learners except the very apathetic ones (Petty, 1995:222).

- It encourages learners to use their higher-order learning skills (Petty, 1995: 225).
- Learners are actively involved.
- Learners are encouraged to see learning as something they themselves do, not as what they are expected to do.

Advantages of independent instruction:

The following are some of the advantages expounded by Avenant (1990:281-282), Killen (1998:104-110), and Jacobs *et al.* (2004:200):

- It engages learners actively in learning and thus learners become more strongly motivated.
- It develops meaningful solutions to problems, leading to learners' remembering the work for much longer.
- It provides challenges to learners and they get satisfaction out of solving problems by using their intellectual skills.
- It assists learners to shape and direct their own learning by utilizing scientific skills such as planning, objectivity, accuracy, etc.
- It creates conditions which assist in the retrieval and appropriate use of new information, and the activation of prior knowledge.
- It makes tuition learner-oriented in that the responsibility for problems, gathered information, forming hypotheses and experimenting is shifted to learners. They therefore develop qualities such as resourcefulness, patience, tenacity and independence.
- It assists learners to master content more effectively for they have an opportunity to think, counterbalance and sift information in order to perceive relationships and concepts, as well as to understand rules and theories. This helps learners to evaluate their own understanding and to identify flaws in their own thinking. Clearly a form of instruction that will

accommodate learners who have a preference for thinking and doing during learning (*cf* 2.4.2).

- It helps learners to become more able to develop their individual abilities because it gives them freedom to investigate, display their initiative, plan solutions and develop their unique talents in the process
- It encourages learners to develop critical and creative thinking skills.
- It encourages learners to debate ideas among themselves and make enquiries regarding the meaning of words and concepts. In this way their vocabulary is extended.
- It makes teacher and learner evaluation easier because during the process of problem-solving the teacher can immediately detect whether learners are actually making any progress, and take appropriate action.
- It promotes interaction and teamwork among learners, thus enhancing interpersonal skills.
- It can be fun and rewarding in that it is both stimulating and interesting.
- It satisfies the natural inquisitive nature of a child.
- If learners are involved; they therefore feel that they are responsible for their learning.
- It motivates learners when they realize that others value their ideas.
- It fosters social interaction.
- It develops learners' analyzing skills.
- Because learners talk, this enables them to construct knowledge continuously until it makes sense to them.
- It is an effective way of allowing learners to share knowledge and different experiences.

- It is non- threatening.
- It promotes the implementation of new ideas.
- Learners learn the importance of weighing facts before reaching a conclusion.
- Learners practise how to handle controversy.
- It assists in the development of critical thinking and problem-solving skills.
- It helps create rapport between teachers and learners and learners and learners.
- It is a good way to allow for differences in learning styles and pace.
- Teachers can pinpoint areas of weakness that learners may have.

Disadvantages of independent instruction:

- It is time-consuming.
- Some learners may drift from the topic.
- Learners may fool around.
- It overloads the teachers with work, since they have to do a lot of research.
- It might frustrate learners who have low self-confidence and those who prefer learning by sensing, feeling and whatching.

2.3.2.4 Interactive instruction

This approach refers to individualized learning. Teachers and learners co-operate in the learning adventure (Grosser, 2001:45). They engage in interactive dialogue. The focus is on thinking, processing information, language skills, dialogue and reasoning. It can also imply that learners are working together and helping one another to achieve outcomes.

This method of teaching gives learners a chance to implement learned principles and vocabulary (Petty, 1995:169). It provides opportunities for learning, for it requires learners to master new learning material and make sense of it on their own. It fosters skills such as creativity, synthesis and analysis.

Table 2.4 Techniques for Interactive Instruction (Grosser, 2001:52)

TECHNIQUE	APPLICATION
Simulations and role play	Each group member assumes the role of a character and plays that role in addressing an issue, e.g. deciding on an anti-smoking law. (Roles: doctor, smoker, tobacco merchant, politician and cigarette factory worker.)
Brainstorming	Learners generate different ideas to solve problems or to discuss an appropriate topic.
Fishbowls	One group sits in a circle facing one another to discuss an issue related to a topic. The rest of the class sits in an outer circle, taking notes and watching. Different groups get a chance to sit in the middle and to discuss different issues. All groups receive a task based on the discussion, to be completed. Each group submits a final report for assessment.
Round Table (written) or Round Robin (oral)	Groups use a single pen and a piece of paper to answer a question/questions in a test. Each group member writes down one sentence/fact before passing the pen and paper on to the next member, who writes the next line/fact and passes it on. Learners may pass an answer. Groups are assessed for their group effort.

Buddy system	Learners are assigned a partner to discuss issues with. Partners discuss questions or check one another's work or share ideas.
Train questions	Groups sit in lines, one member behind the other. The educator or other groups pose questions (oral or written). The first member answers or passes it on to the next person. If the question/questions is/are unanswered at the end of the line, the group loses marks.
Telstar techniques	Each group elects a spokesperson to debate an issue. All spokespersons sit in an inner circle to debate. Members of the groups may pass notes, suggestions or ideas on to the spokesperson from the outside of the circle.
Numbered-Heads Together	- Numbers are allocated to group members. The educator asks questions. Group members decide on a correct answer. The educator calls a certain number to provide the correct answer.

According to Killen (1998:64) and Petty (1995:169), the advantages of interactive instruction include the following:

- Learners, opinions are valued and accepted.
- Teachers get an opportunity to make use of learners' views and experiences.
- It instills values such as loyalty, sharing and respect.
- It allows teachers to vary tasks according to the diversity of learners.
- Learners are all given a chance to participate.
- It enhances learners' achievement and relation.

- Learners learn to be less dependent on the teacher.
- It encourages multiple approaches to one problem.
- It trains learners in acceptable roles such as leaders, peers, subordinates.
- It is fun and useful in activating learners' prior knowledge.
- It gives teachers a chance to attend to individual learners.

Disadvantages of interactive instruction refer to the following:

- Some learners may hide behind others if the teacher is not vigilant.
- Faster learners may be bored by the slower progress of others.

2.4 LEARNING STYLES

Human-beings are different and unique individuals. Each individual has his/her unique way of doing things. Confronted with the same situation, people will react differently to it. Peoples' perceptions and interpretations of the same event are hardly ever identical (Kruger & Adams, 2002:211). This understanding holds true for learners in any given teaching learning situation.

Very little attention has been given to differences among learners. Teachers often claim that they teach all learners in the same way (Kruger & Adams, 2002:213). This, they believe, is an accepted professional way of showing that they are not biased, nor segregative. Much as this is a socially accepted principle, research has shown that treating learners uniformly does not always yield good and successful results (Kruger & Adams, 2002:215). Because every learner has unique talents, potentials, abilities, as well as shortcomings, it is necessary for teachers to recognize, acknowledge and cater for these assorted needs in order to promote learner performance and competency.

Kruger and Adams (2002:215) advise that teachers need to characterize learners in such a way that their individual characteristics are adequately addressed. They advice that, in order to do this, teachers should:

- acknowledge the differences that exist among learners;
- recognize that such differences may impact on how learners learn; and
- plan and implement learning programmes which respond to these differences.

This identification should be done within the prescriptions of supporting and promoting learning and NOT to label and stigmatize learners. Teachers should take serious note of this or they might fall into the trap of stereotyping or favouring some learners at the expense of others.

A learning style refers to the way in which learners approach tasks and process information. Learners learn in different ways and at different paces. One of the central ideas behind the Outcomes-Based Education system is that learners learn differently and thus cannot be expected to achieve outcomes in the same way (Grosser, 2001:11). A broad understanding of learning styles will help educators to understand and support learning through different stages of the learning process. The following are examples of learning styles:

2.4.1 Gardner

This model lists seven learning styles (Grosser, 2001:15)

- The linguistic: certain learners like reading, writing and telling stories. They like using languages and are good at memory tasks. They learn best by talking, listening and seeing.
- The logical/mathematical: They like experimenting, exploring, manipulating figures, asking questions, reasoning and solving problems. They are good at figures and logical thought. They learn best when they have to classify and categorize, using abstract thinking.
- Spatial: They like to draw, design, create, daydream, watch movies and play with machines. They enjoy puzzles, reading charts and are good at

imagining and sensing change. They learn best when they have to use their mind's eye.

- Musical learners: - They like singing and listening to music. They continuously hum tunes. They are good at picking up sounds, noticing pitches, rhythms. They learn best by rhyming or listening to music.
- Bodily /Kinetic: These learners like to move about, touch, use body language and talk. They learn best by moving, touching, interacting with space. They are good at sports, dance, acting, crafts.
- Personal: they prefer working alone. They are good at self-analysis, following instincts, pursuing own interests and being original. They learn best when they work alone at individual assignments and self-paced tasks.
- Interpersonal: They like talking to others and joining social and didactic groups. They have lots of friends and are good at understanding people, organizing, leading, communicating, manipulating and resolving conflict. They learn best by sharing and comparing information, relating, cooperating and interviewing.

2.4.2 Kolb

Kolb also identifies four types of learners (Kolb, 1984):

The Converger (sensor and feeler):

- they like to see, feel and hear in order to learn; and
- they learn from games, role plays and other actions;

The Diverger (watcher)

- combines concrete experience and reflective observational learning steps;
- can interpret concrete situations from many points of view;
- prefers observing to taking part in tasks;

- enjoys brainstorming sessions; and
- they like lectures and demonstrations.

The Assimilator (thinker):

- combines abstract conceptualization and reflective observational learning steps;
- good at understanding a variety of information and putting it together; and
- they like to analyze logically and create understanding for themselves.

These characteristics are essential for learning in the Natural Sciences.

The Accommodator (doers):

- combines concrete experiences and active experimentation;
- learn best through hands-on experience;
- enjoys new challenges; and
- they prefer practice to theory.

2.4.3 Rosenberg

Rosenberg, as quoted by Hamachek (1995:247-250) identifies four styles.

- **The rigidly-inhibited pattern:** Learners using this pattern are those who learn best when directed by the teacher. These learners tend to be uncertain and anxious if left to make their own decisions.
- **The undisciplined pattern:** Learners exhibiting this pattern tend to be unruly and undisciplined. They have a tendency to be destructive, lie, steal, answer back to teachers with disrespect, do not finish their work and have a low threshold for frustration. They learn better when their work is properly structured, instructions are very precise and the teacher is firm. These learners rely more on the teacher for control.

- **The acceptance-anxious pattern:** These learners are those who are concerned about others' opinion. They need approval and acceptance of others, more than thinking about their school work. They are afraid of being judged negatively and therefore they often fear to make decisions in case they are wrong. These learners do not easily accept that being wrong is part of learning. These learners do their best when guided by a warm, understanding teacher, but flounder when the teacher becomes harsh and authoritative. They need to be made aware that they can make mistakes without fearing that others will ridicule or embarrass them.
- **The creative pattern:** Those who use this pattern are often confident, think divergently, evaluate their performance objectively, enjoy competition, like solving problems and take advantage of opportunities that call for use of imagination. They prefer open-ended tasks where they have the latitude to exercise their creativity. They learn best by exploring, searching, manipulating, testing the limits and playing.

2.4.4 Whitaker

The four types of learners as described by Whitaker (1995:16) are:

- **Attention-Seekers:** These spend most of their time moving about in the classroom in search of the teachers' and other learners' attention.
- **Intermittent Workers:** These learners get distracted frequently, that is, they perform their tasks at intervals. They do not begin and complete their task without flitting from one conversation to another.
- **Solitary Workers:** These learners tend to keep to themselves. They watch while other learners receive attention from their peers and teachers. They receive the least attention. They prefer to work alone.
- **Quiet Collaborators:** These are learners who put up an appearance of being busy and co-operative, but who, in effect, rely heavily on teacher support. They do not venture on their own, but await the teacher's support.

Whitaker (1995:17) further unfolds differences among learners by distinguishing four distinct learning styles, namely:

- **Reflector** - reflecting on concrete experience and drawing conclusions.
- **Theorist** - reflecting on data and information and developing ideas.
- **Pragmatist** - thinking about problems and trying out possibilities.
- **Activist** - trying out ideas, responding to challenges and taking risks.

2.4.5 Seeler

The ten types of learners as identified by Seeler (1994:73-75) are:

- **The incremental learners:** these learners learn by increments, as the name suggests. This means that small bits are learnt in a step-by-step systematic manner. Then the bits are later added together to form a whole. These learners have to be supplied with programmed instruction.
- **The sensory-specialist learners:** These learners depend on one sense for learning. If they learn best by listening, it is listening they will use, with exclusion of the rest of the senses. This is not a cultivated or preferred habit, but an innate one, and there is not much that can be done to change it.
- **The sensory generalists:** These learners use more than one, if not all, their senses to learn.
- **The intuitive learners:** These learners are guided by intuition more than reason and logic. They are unsystematic and they find it difficult to explain how they reached their findings. Their data gathering is often sloppy.
- **The open-ended structured learners:** These learners learn best when left to explore. They resist structured learning and they often make attempts to redefine learning instruction, should they deem it too restrictive.

- **The explicitly structured learners:** These learners learn best when goals and objectives are clearly stated in the most unambiguous terms. They need to know, in precise terms, what they should do, how they should do it, what resources to use, what format of reporting to use, and how long they are expected to take to perform the task.
- **The emotionally involved learners:** These learners thrive in a learning environment that creates a sense of open discussion and active debate, where healthy disagreements are at the order of the day. They like competition, constructive criticism and arguments.
- **The emotionally neutral learners:** These learners work best in a situation where there is very little emotional or interpersonal conflict. They prefer low-key, task-orientated environments. They react verbally or physically aggressive to the slightest provocation of interpersonal conflict.
- **The damaged learners:** These learners are likely to avoid or reject learning, because of the damage to their self-concept, intellect, aesthetic appreciation or social competency. These learners need psychological intervention to repair the damage and restore their self-confidence and self-worth.
- **The electric learners:** As the name implies, these learners flow with the current. They adjust from teacher to teacher without any effort.

2.4.6 Dunn

Dunn's Model (DoE, 2004b:60-64) comprises five types of learners:

- **The visual learners:** They learn best from seeing or reading. They need to see the teachers' body language and facial expressions. They prefer sitting in front to avoid being visually obstructed by other learners. They take detailed notes to absorb information at leisure through reading.
- **The kinetic learners:** Kinetics implies movement. These learners learn better when they move and become physically involved.

- **The tactile learners:** They like manual manipulation of the material, that is, writing and drawing.
- **The tactile/kinetic learners:** They enjoy role-playing and simulations. They learn best through a hands-on/minds-on approach by actively exploring their surroundings. They do not like sitting still for long periods.

2.4.7 McCarthy

McCarthy's model (DoE, 2004b:60-64) identifies four types of learners:

- **Innovative learners:** They are interested in finding reasons for learning. They need to know why they have to learn what is presented to them, how this new information is useful in their daily life. They prefer using co-operative learning, brainstorming, and integration of content areas.
- **Analytic learners:** They prefer to acquire facts in order to comprehend the deeper meaning of concepts fully. They enjoy research, analyzing data and listening to experts.
- **Common sense learners:** They want to find out how things work. They investigate, explore and engage in concrete learning activities such as conducting experiments. They like doing things.
- **Dynamic learners:** They rely heavily on their own intuition and delight in teaching themselves as well as others. They are interested in self-directing discovery.

2.4.8 Tilstone

Tilstone (2000:35) have also identified four major learning style groups. These are the Wholist-Verbaliser; Wholist-Imager, Analytic-Verbaliser and the Analytic-Imager. The following is an illustrated continuum between the four.

WHOLIST-VERBALISER	ANALYTIC-VERBALISER
WHOLIST-IMAGER	ANALYTIC-IMAGER

This is referred to as a continuum because no one learner fits neatly into one, but can be anywhere in between the four, either vertically or horizontally.

2.4.9 The Free State Department of Education

The Free State Department of Education Manual for implementation of the NCS (2004b:60-64) identifies three models of learning styles to be utilized for the implementation of the new curriculum, namely the models of: Dunn, Kolb and McCarthy. All of these models contain strong links, but for the purpose of this study the focus will be on the model of Kolb (*cf* 2.4.2).

2.4.10 The implications of learning styles for the learning process

According to Whitaker (1995:17) it is important that teachers should have adequate knowledge of learning styles and the stages of the learning process, for the following reasons:

- Teachers need to vary their teaching methods and strategies as well as the learning activities and tasks, to accommodate the diverse needs of learners.
- It is useful in helping teachers to understand and plan instruction.
- Teachers are advised that they need to be guided by the diversity of learner needs in planning for instruction, for the provision of instruction and in their assessment of learning outcomes (Whitaker, 1995:18).

To conclude, Choate (1993:37) states that a central element of differentiated instruction is identifying and teaching according to an individual's learning style and the set of instructional conditions that facilitate a specific student's academic progress. These conditions include not only the preferred learning modality, but also such features as light, sound, time, temperature, grouping and degree of structure.

A normal classroom will have learners with many learning styles or combinations of learning styles. The disadvantages of always teaching in the same way or providing similar learning opportunities are clear. Some learners will always enjoy lessons and do well, while others struggle all the time. In time, some learners are seen as good, dedicated and talented, while others are labeled slow, bored or difficult (Grosser, 2001:16-17). It is however also important to expose learners to all the different learning styles, as learners also need to learn to adapt to learning styles which they might not favour (

By understanding how to cope with learning styles educators may be able to avoid the aforementioned familiar set of problems of many educators. Outcomes-Based Education acknowledges these differences and seeks feasible ways of allowing learners to use different ways to show their achievement (Grosser, 2001:18).

Honey and Munford, as quoted by Whitaker (1995:17), suggest that irrespective of which learning style the learners prefer or which learning mode they engage in, they incorporate these four stances: *learning by feeling, by watching, by thinking or by doing*. It is believed that although modes and styles are interdependent and intradependent, learning in the emotional mode gives most nourishment to the entire learning process (Whitaker, 1995:18).

2.5 ASSESSMENT

Having dealt with teaching and learning in the two previous sections, it becomes necessary to address the issue of assessment briefly, without which both teachers and learners would not know whether the expected outcomes and objectives have been achieved.

The term assessment is broadly used to define processes of appraising learner performance (Lefrancois, 1997:457). These processes could include elements of evaluation and measurement, which are both important parts of the instruction learning process. For better clarification of the concept assessment, a difference has to be drawn between the two terms “evaluation” and “measurement”.

Evaluation involves making a value judgment (Crowl, Kaminsky, & Podell, 1997:310; Lefrancois, 1997:456). It decides on the success or failure of performance. It is concerned with. *Measurement* denotes the use of an instrument to gauge the quantity of a substance or entity as opposed to this quality.

2.5.1 Approaches to assessment

There are two approaches to assessment, namely assessment of learning and assessment for learning.

2.5.1.1 Assessment of learning

Traditional approaches which view learning as a product and therefore rely on assessment that focuses on reproduction are collectively referred to as assessment of learning approaches (Willis, 1993:38). This approach requires learners to memorize learning material over long hours and then reproduce it during examination time (Willis, 1993:385). Learners, who do not have the ability to engage in such tedious tasks and fail examinations, lose interest in learning.

2.5.1.2 Assessment for learning

Approaches that focus on holistic learner-centred, performance-based and process-oriented appraisal are termed assessment for learning. The traditional assessment of learning approaches was modified into the modern approaches because educationalists realised that the former methods only assess the end product (summative) and neglect the process that leads to this product (Barootchi & Keshavarz, 2002:280). The latter approach to assessment occurs during teaching and learning, as opposed to the former, which occurs after teaching.

In assessment for learning, emphasis is placed on progress and achievement, rather than on failure and defeat (Stiggins, 2000:759; Dochy, Moerkerke & Martens, 1996:329). This, according to Willis (1993:385), increases learners'

motivation and confidence because they are involved in the assessment activities.

Since assessment for learning involves day-to-day classroom assessment activities, use is made of portfolios. These are a collection of all the assessment activities by the learner which are going to be evaluated. They form what is called Continuous Assessment.

2.5.2 The purposes of assessment

Assessment serves a number of purposes, some of which are:

- To find out why learners are doing something wrong. This is sometimes referred to as diagnostic assessment. It is a way by which teachers and learners ascertain what learners have or have not managed to master and why this happened. It helps to redirect teaching, to address whatever barrier could have caused the learner not to achieve (Kruger & Adams, 2002:197).
- To select learners for specialised courses. Assessment for this purpose is not relevant to this study and will therefore not be discussed. Suffice it to say that this kind of assessment is applied by institutions other than the classroom and that Outcomes-Based Education discourages it (Kruger & Adams, 2002:197).
- To determine how good the teaching is. This could be done through assessing learners' competencies and skills. Lewis, as quoted by Kruger and Adams (2002:198), purports that teaching is an inverse of learning. The level of learning achieved by learners often serves as a barometer for gauging the teacher's management of the teaching process (Kruger & Adams, 2002:198).
- To allow learners to continue with new work. Outcomes-Based Education demands that new work should not be undertaken until all the prerequisite work has been mastered. It is therefore important to establish whether

learners have acquired the necessary skills before continuing with new work (Kruger & Adams, 2002:198).

- To motivate learners. Learners are motivated when they get positive feedback on their performance. This inspires them to do even better and their confidence is boosted (Kruger & Adams, 2002:199).
- To determine whether good standards are being maintained. This is to measure the quality of what learners know and are able to do (Kruger & Adams, 2002:200).
- To predict future success. If properly assessed, the learners' performance could serve as a prediction or forecast of their future achievements (Kruger & Adams, 2002:201).
- To acknowledge learners' efforts. Learners need to be assured that teachers take interest in their work. They become disgruntled if they observe that a teacher has not checked their work and they consequently rate that teacher as a non-caring one. Learners' work should therefore be scrutinized carefully and promptly and returned to learners with appropriate remarks (Capel *et al.*, 2003:298).
- To monitor progress. This serves to monitor the learners' understanding and to diagnose those factors which might inhibit effective learning (Capel *et al.*, 2003:298-299).
- To establish baseline evidence of achievement. An audit of what each learner can or cannot do is done at the beginning of a school year. This is to form a baseline for any future progress (Capel *et al.*, 2003:301).
- To detect learners' under- or overachievement. Assessment should recognize learners' abilities and potential, as well as previous educational performance. This aids in identifying those learners who underachieve and those that need acceleration (Capel *et al.*, 2003:301).

- To report to parents. Most parents are keen to know of their children's school progress. Formative and summative assessment serves the purpose of providing this information to parents (Capel *et al.*, 2003:302).
- To account to the public. The public needs to know how the Education Department, as well as public schools, is performing. Assessment results, especially end-of-course achievement results are used to compare schools and applaud or reprimand them accordingly. Politicians use these results as a tool (Capel *et al.*, 2003:303).

2.5.3 The principles of assessment

According to Outcomes-Based Education, assessment should be based on four principles, namely design-down, clarity of focus, high expectations and expanded opportunities (DoE, 2004a:70-72).

2.5.3.1 Design-down

This means that outcomes of the learning matter have to be specified clearly before developing teaching and learning activities to be engaged in. Slavin (1997:483) emphasizes that learning and teaching objectives have to be linked with assessment. He further admonishes teachers to consider learners' skills and levels of understanding when they determine outcomes and assessment. In one lesson, he suggests, there could be activities demonstrating different levels of skills and understanding of the concept under discussion, with different lesson goals. These are called taxonomies and they help teachers to categorize teaching activities. The most commonly used taxonomy of educational objectives is that propounded by Bloom *et al.*, often referred to as Bloom's Taxonomy for the cognitive domain (Bloom, 1976). It is the ordering of objectives from the simple learning tasks to the more complex ones (Slavin, 1997:484-485). It comprises six levels arranged, in a hierarchy of ascending order (Crowl, Kaminsky & Podell, 1997:292-293). Starting from the lowest they are :

- **Level 1: Knowledge**

Outcomes at this level emphasize psychological processes of memorizing and remembering information presented to the learners. Questions at this level that are related to knowledge outcomes would be such as:

- **Level 2: Comprehension**

These objectives expect learners to demonstrate an understanding of the information presented.

- **Level 3 : Application**

This implies using information to solve problems, whether abstract or from real life.

- **Level 4 : Analysis**

Learners are required to break down complex information or ideas to simpler, less complex facts.

- **Level 5 : Synthesis**

Learners are expected to be able to find connections and relationships between ideas and to create something out of them that did not exist.

- **Level 6 : Evaluation**

At this level, learners examine and judge ideas against given criteria. Learners are asked questions that require making value judgements.

It is imperative that teachers keep these six levels in mind when planning instructional objectives and hence assessment.

2.5.3.2 Clarity of focus

This means that teachers have to make sure that learners are clear about what they are expected to be able to demonstrate and what criteria they are going to be assessed against.

2.5.3.3 High expectations

Outcomes-Based Education is learner-paced and learner-based. Teachers are therefore expected to assist learners to reach their full potential. Emphasis should be on measuring learners' progress against their previous achievements and not against those of other learners. Learners should be allowed to demonstrate their competencies in accordance with their potential and abilities.

2.5.3.4 Expanded opportunities

Teachers have to devise various ways of learning and assessment opportunities that will create a climate to evoke learners' full potential of skills, knowledge, values and attitudes.

It is with this in view that alternative methods of assessment have been designed to give all learners equal opportunities to display their competencies in a manner most convenient to them. This is done without compromising standards or giving learners an unfair advantage over others.

Other principles of Outcomes-Based assessment include the following aspects:

- providing of tools which appropriately assess learners' achievement;
- measuring learners' achievement against learning outcomes, using a variety of methods such as oral questioning, conferencing, interviewing, standardized tests, observation, peer assessment and self-reporting;
- requiring cumulative evidence of learner achievement to be recorded and kept throughout the learners' education path;
- insisting that reporting has to be part of learning and teaching;
- assisting learners to reach their full potential;
- being participatory, democratic and transparent;

- involving learners actively, using relevant knowledge in real-life situations;
- being integrated throughout the teaching and learning process;
- being used for support and enrichment;
- being linked to individualized performance-based assessment; and
- offering a variety of ways in which to assess different dimensions of learning styles.

2.5.4 Types of assessment

Different types of assessment are used for specific purposes. For the purposes of this study, the focus will be on baseline, formative, summative, continuous, norm-referenced, criterion-referenced and performance-based assessments.

2.5.4.1 Baseline assessment

This is used to find out how much prior knowledge learners have about the subject to be discussed. This helps the teacher to have a better idea of the level at which the learners are and guides him/ her as to where to begin, what instructional methods, techniques and language to use (Crowl *et al.*, 1997:321; DoE, 2003:6).

2.5.4.2 Formative assessment

This is assessment done during units of instruction to measure progress in order to guide the content and pace of both teacher and learner (Slavin, 1997:491). Its aim is to give ongoing feedback during instruction to enable both the teacher and the learners to identify what has been or has not been learned. Its major purpose is to provide guidelines to change instructional methods and pace, or to give support to certain learners who might need it (Crowl *et al.*, 1997:322; DoE, 2003:6).

2.5.4.3 Summative assessment

This is done at the end of an instruction unit to determine whether learning has taken place or not and how much of the instructional objectives have been achieved (Crowl *et al.*, 1997:322; DoE, 2003:6). It is used to summarise learners' achievement and often also to determine progression to a higher level of education (Capel *et al.*, 2003:289).

2.5.4.4 Norm-referenced assessment

This type of assessment focuses on comparing the score of a learner to those of others or to a nationally representative norm group (Slavin, 1997:491).

2.5.4.5 Criterion-referenced assessment

This focuses on establishing whether learners have acquired the specific skills and knowledge, regardless of how others performed on the same skills (Slavin, 1997:491). It measures which instructional objectives learners have mastered and is most useful in detecting learners with special education needs such as slow learning and giftedness (Crowl *et al.*, 1997:323).

2.5.4.6 Performance-based assessment

This assessment attempts to determine learners' competence by looking at what they have actually done that relates to real life activities (Lefrancois, 1997:487). It requires learners to document their learning or show that they can use the learned information in real-life situations (authentic assessment) (Slavin, 1997:507). Performance assessments are designed to force change in what learners learn at schools (Pressley & McCormick, 1995:431).

This assessment method, says Kruger and Adams (2002:207), uses portfolios. Pressley and McCormick (1995:434); Lefrancois (1997:489); and Crowl *et al.* (1997:331) all concur that portfolios are used for better performance-based assessment.

Portfolios are a collection of the learner's entire achievement throughout the school year. These can be in the form of actual samples of the learner's work,

records of tests scores, their knowledge, ability and attitudes towards their work. It is a file of the learner's work. What should be included in the learner's portfolio should be decided at the beginning of the year by both the teacher and the learner. This decision should be in line with the circular requirements and the expected learning area outcomes and critical and developmental outcomes. Two types of portfolios are identified as:

- a product portfolio which includes only the best and final examples of the learner's work;
- a process portfolio which indicates how a learner carries out a task.

2.6 SUMMARY

Without a thorough knowledge of the theories underlying teaching and learning, the variety of teaching styles and methods, the variety of learning styles and assessment strategies, teachers will not be able to deal with diverse learner needs in their classrooms. The interconnectedness of learning theories, teaching styles, teaching methods, learning styles and assessment strategies is depicted in the table below:

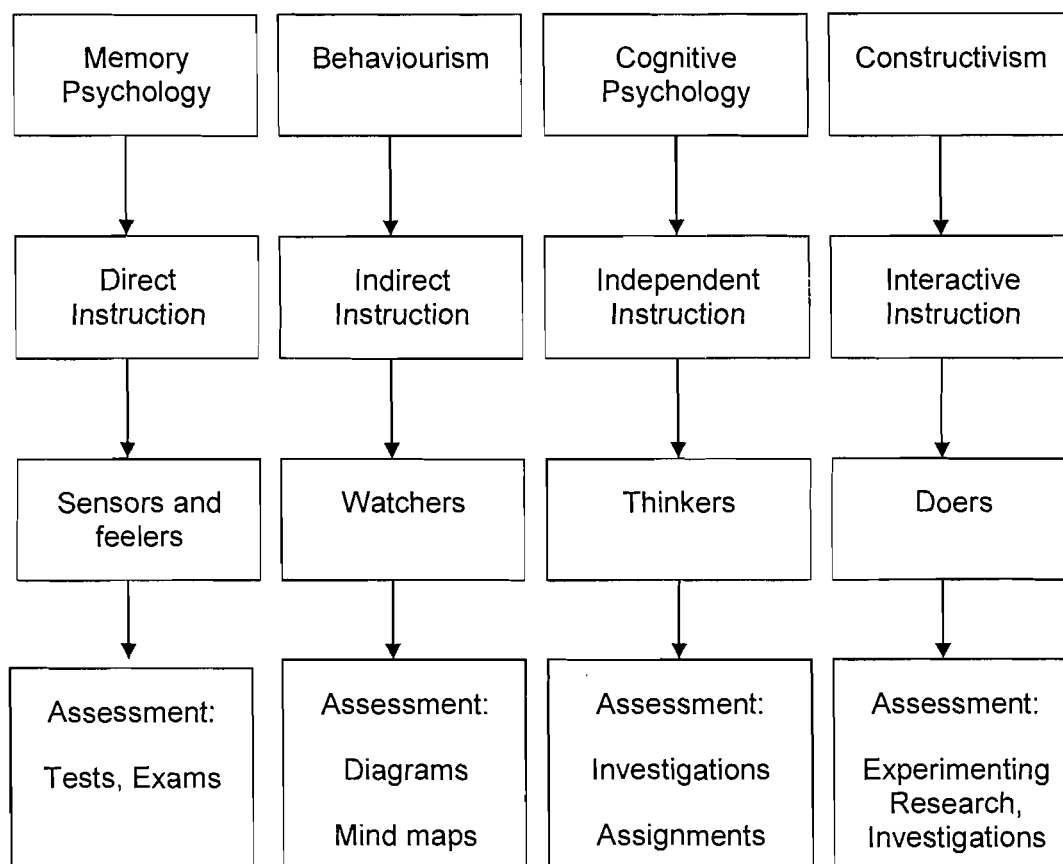


Figure 2.3: The interconnectedness of learning theories, teaching styles, learning styles and assessment strategies

It is evident from the above table that all theories underlying teaching and learning should be evident in the planning of a teaching and learning experience. It is indicated that each learning theory encompasses a certain way of teaching and assessing which in turn will accommodate a specific learning style. To cover the whole spectrum of diverse learning styles it is of utmost importance that all learning theories should underpin the planning of teaching and learning experiences. If this does not happen, addressing diverse learner needs could remain an ideal.

2.7 CONCLUSION

In this chapter, the generic theoretical foundation was laid for the design of a teaching and learning programme in which the diverse needs of all learners are addressed (*cf* 6.2). The next chapter will attempt to link the theory more specifically with teaching, learning and assessment in the Natural Sciences.

CHAPTER THREE

LINKING TEACHING, LEARNING AND ASSESSMENT WITH DIVERSE LEARNING STYLES IN THE NATURAL SCIENCES

3.1 INTRODUCTION

In the previous chapter, this study focussed on a generic discussion of teaching styles, methods, strategies, assessment strategies as well as learning theories and learning styles. This chapter will attempt to link all that was discussed in the previous chapter with the teaching of the Natural Sciences. In order to achieve this intention, the chapter outline will be as follows:

- exploring the nature of Sciences;
- the purpose of Natural Sciences;
- South African policy of the Natural Sciences - Grades R - 9 (National Curriculum Statement);
- teaching styles, methods and strategies most appropriate for teaching the Natural Sciences in the senior phase (Grade nine); and
- assessment strategies appropriate for the Natural Sciences in the mentioned phase (Grade nine).

3.2 THE NATURE OF SCIENCE

Science, according to Stevenson and Palmer (1994:48-50), has to be part of the entire school curriculum that is broad, balanced, relevant and differentiated. This means that it should be part of all learning (broad), it should cover all aspects equally (balanced), it should address issues of everyday life (relevant) and it should respond to individual differences (differentiated).

Science is defined by Carin and Sund (1989:4) as the system of knowing about the universe through data collected by observation and controlled experimentation.

The process of data collection leads to formulation of new theories which explain what has been observed. A theory can be verified in these three ways:

- it should be able to explain what was observed;
- it should be used in predicting what has not yet been observed; and
- it should be subjectible to further tests through experimentation and applicable to new data.

John Rigden, as quoted by Stevenson and Palmer (1994:49), identifies two characteristics of the nature of science; the empirical character of science and its analytical nature (Stevenson & Palmer, 1994:49).

3.2.1 Empirical nature of science

This means that in order to acquire scientific knowledge, one has to interact directly with the universe by making observations or experiencing the effects of the universe directly. This is done through the processes of exploration, investigation and description of objects and situations (Stevenson & Palmer, 1994:49).

3.2.2 Analytical nature of science

Procedures such as experimentation and investigation that lead to the discovery of hidden laws, principles, meanings and explanations subscribe to the analytic nature of science. During these procedures, data is collected and analysed and conclusions that lead to the formulation of laws or principles, as well as giving meaning to ideas and concepts, are drawn.

The interaction between the analytic and empirical results is what is termed science. These interactions involve the scientific processes, products and human attitudes. Scientific products comprise facts, concepts, principles,

laws, theories and generalisations. Scientific processes or methods such as exploration, experimentation, observation and investigation lead to knowledge acquisition and change of attitude. All of these together form science, (Stevenson & Palmer, 1994:50).

Trowbridge and Bybee (1990:48-49) list five features to illustrate the nature of science. They posit that science is:

- both tentative and stable;
- public;
- empirical;
- replicable; and
- historic.

3.2.3 Science is both tentative and stable

Science is said to be tentative because it is subject to change. As new information is gathered and knowledge acquired, existing ideas are challenged and probably altered. Science is therefore not absolute, nor does it supply permanent explanations to phenomena. It allows and assists in the formulation of predictions and hypotheses. It is stable because scientific processes, more often than not, result in either reconstructing or modifying existing ideas and knowledge. The product never completely refutes existing knowledge.

3.2.4 Scientific knowledge is public

New scientific knowledge and the methods used to discover it have to be made public. This is done so that others can have access to this information and use the same methods to validate or explain phenomena.

3.2.5 Science is empirical

Validation or refutation of scientific knowledge is based upon observation and experimentation of what occurs in the physical world, as mentioned earlier.

3.2.6 Scientific knowledge is replicable

This implies that because scientific knowledge is public, anyone should be able to use the same methods under similar conditions and get the same results, irrespective of where they are.

3.2.7 Scientific knowledge is historic

Previously acquired scientific knowledge forms the basis of current knowledge which in turn forms the basis of future knowledge. Scientific knowledge is thus cumulative. The context in which science is understood is social, political technological and time-based.

Having outlined the nature of science in general, time should be taken to introduce the Natural Sciences, specifically as they form the core and basis of this study. The structure, feature and purpose of the Natural Sciences as a learning area in South Africa will be discussed in the ensuing paragraphs.

3.3 INTRODUCING THE POLICY

The National Curriculum Statement (NCS) is based on the notion that education has to be learner-centred, in order to enable all learners to attain their maximum potential and hence achieve what needs to be achieved. South African Education aims to develop the full potential of learners, hence the OBE approach.

3.3.1 Structure of the Natural Sciences

Natural Sciences is a generic phrase used to denote that area of science that studies how and why phenomena behave the way they do. In other countries it is referred to as integrated science. The Natural Sciences are made up of four strands (DoE, 2003:24). These strands comprise the domain of knowledge, namely:

3.3.1.1 Life and living

This is further divided into sub-strands, namely life-processes and healthy living, interactions in environments and bio-diversity, and change and continuity. This section studies all living things, e.g. plants and animals, how they behave, especially in their natural habitats, the life processes that occur within them and the functions of their systems.

3.3.1.2 Energy and change

This strand comprises two sub-strands, namely energy transfers and systems, and energy and development. This is what used to be referred to as Physics. It concerns itself with the study of the properties and interactions of matter and energy. Specifically this section deals with energy transfers and sources of energy.

3.3.1.3 Planet earth and beyond

Traditionally this is referred to as Geography. This is the study about the earth, its physical features, its climate, the population and resources on it. The sub-strands of this strand are: our place in space, atmosphere and weather, and the changing earth.

3.3.1.4 Matter and materials

This was known as Chemistry. It deals with the study of elements and the compounds they form, and the reactions they undergo. The sub-strands are: properties and uses of materials and structure, reactions and changes of materials.

These strands cover what is termed the scope of the content and context of Natural Sciences in South Africa.

3.3.2 Unique features of the Natural Sciences

The Natural Sciences as a learning area has features that separate it from other learning areas. These are outlined in the policy document of NCS (DoE, 2002:5) as:

- the way in which information is gathered and interpreted;
- the way in which information is verified before general acceptance;
- the acknowledgement of limitations of scientific enquiry; and
- the domain of knowledge that is covered.

The last of the four bullets was discussed previously when the four strands were discussed. The strands form the domain of knowledge comprising the Natural Sciences learning area. The other three will be looked into briefly.

3.3.2.1 The way in which information is gathered and interpreted

Science endeavours to answer the questions: what? why? how? It seeks to find reasons how and why things happen the way they do. Scientists continually seek cause and effect, that is: why and how it happens and the effects it has on others (Carin & Sund, 1989:11). The “what” questions are relatively easier to answer because they require descriptive answers only.

The “how” questions pose a more difficult task to answer. Scientists have to engage in inquiry process skills to reach the answer. The “why” questions are the most difficult to answer, as they often do not provide a final answer. One answer leads to another question to explain the answer provided (Carin & Sund, 1989:10).

The way in which these questions are answered requires scientific processes used specifically in scientific inquiry. The most basic are: observing, classifying, measuring, hypothesising or predicting, describing, inferring or making conclusions from data, asking insightful questions about nature, designing investigations including experiments, carrying out experiments and constructing principles, laws and theories from data (Carin & Sund, 1989:11). The interpretation of the data is often done by the use of process skills such as analysis and synthesis.

3.3.2.2 The way in which information is verified before general acceptance

As mentioned earlier, scientific knowledge is public and as such it has to be verified before it is published for public consumption. This is done through a series of tests. Edwards, Scalon and West (1993:16) believe that scientific knowledge goes through an argument among scientists, involving a complex interplay of theoretical statements, experimentation, validation and personal opinion.

They list a set of criteria that scientific knowledge has to meet before it can be accepted. These are:

- elegance and simplicity, that is, the beauty of science;
- similarity and consistency with other theories;
- intellectual fashion, this implies compatibility of the findings with current trends and articulations in other disciplines;
- social and economic considerations;
- cultural considerations;
- the status of the researcher;
- the views of other significant role players such as influential and powerful scientists, journal editors, publishers, etc.; and
- priorities of research funding agencies (Edwards *et al.*, 1993:17).

This gives us a clear indication of the gruelling procedure scientists have to follow before they can declare their findings as valid knowledge.

3.3.2.3 The acknowledgement of limitations of scientific enquiry

Scientific knowledge or products such as theories, principles and laws are statements of conjecture. They are not absolute truths, but instruments used to describe the world and are therefore subject to critical scrutiny (Edwards *et*

al., 1993:13). Scientists therefore acknowledge this fact and admit that their discoveries are just theoretical models which are their current best shot at the real truth. This is why it is not surprising when new theories are formed to replace or augment existing ones about the same phenomenon.

The Natural Sciences forms but a small part of the learning areas prescribed for secondary school. To understand it better, one needs to find its place in the policy, the National Curriculum Statement.

3.3.3 The purpose of the Natural Sciences

The Natural Sciences, as a learning area, aims at promoting scientific literacy through the following domains:

- development and use of science process skills in a variety of settings;
- development and application of scientific knowledge and understanding; and
- appreciation of the relationships and responsibility between science, society and the environment (DoE, 2003:4).

The three domains can be unpacked as follows:

3.3.3.1 Development and use of science process skills in a variety of settings

Learning theorists, as was explained in Chapter two, maintain that individuals have innate capabilities which are naturally nurtured by the environment within which they exist. Maslow adds that all humans follow a specific trend of development to satisfy their natural needs. These are called Maslow's Hierarchy of Needs. Maslow posits that humans are driven by a need to acquire ultimately the full use of their potential, talents and creativity (Hamachek, 1995:47).

Carin and Sund (1989:44) and Trowbridge & Bybee (1990:372) concur with the statement above. Science process skills are lifelong skills that humans

use to go through Maslow's hierarchy of needs which are (starting from the lowest to the highest level):

- psychological needs - needs for food, water, sleep;
- safety and security - need for structure, stability and order;
- love and belonging - need for friendship and acceptance;
- self-esteem - mastery needs, competence, status, dignity achievement;
- self-actualisation - full use of talents and potential.

Carin and Sund (1989:6) agree with Maslow about human-beings being driven by natural innate forces to find meaning of their world. This is how they put it:

Human urges and needs are the forces that drive people to seek rational answers to questions about their world. These forces were the catalyst for the development of science. Young children enjoy discovering the texture, size, weight, color - even taste - of sand at the seashore, in the sand box because sand intrigues them.

The policy (DoE, 2002:13) enumerates eleven process skills that need to be fostered and used from Grades R - 9. These are:

- observing and comparing : learners observe phenomena and note similarities and differences;
- measuring : using relevant instruments accurately to find quantity, distance, etc;
- recording information: learners have to report their findings and observations for further use;
- sorting and classifying: learners have to be able to choose a system or rules by which they can group items;
- interpreting information: learners create meaning out of collected data;

- predicting: learners use knowledge to decide what would happen if they manipulated conditions;
- hypothesizing: stating reasons or causes for something that happened;
- raising questions about a situation: questions about how and why things are as they are, can be answered by scientific methods;
- planning scientific investigations: this is where learners follow certain procedures, under certain conditions, to find solutions to problems or explanations to phenomena;
- conducting investigations: the actual process of manipulating variables, measuring, interpreting, reporting and inferring occurs; and
- communicating scientific information: learners reflect on their own learning. This involves giving oral reports, writing texts, using art, graphs, posters or diagrams.

3.3.3.2 The development and application of scientific knowledge and understanding

Learners have their own interpretation and understanding of the world they live in, as mentioned earlier. Scientific knowledge helps them to make more sense of natural phenomena and to remove misconceptions they might have formed (Alsop & Hicks, 2001:27). Scientific knowledge and understanding also helps learners to understand the basis for decisions taken in a world that is increasingly becoming technological (Alsop & Hicks, 2001:27). The National Curriculum Statement (2002:4) states that scientific knowledge and understanding is a cultural heritage. This statement is endorsed by Alsop and Hicks (2001:31). These authors maintain that scientific knowledge is an important part of contemporary culture. They assert that through science, humans understand the universe better and this understanding is portrayed in the form of art and poetry.

The NCS (DoE, 2002:4) lists four uses of scientific knowledge and understanding:

- It answers questions about the nature of the physical world.
- It prepares learners for economic activity and self expression.
- It lays the basis for further studies in science.
- It prepares learners for active participation in a democratic society that values human rights and promotes environmental responsibility.

3.3.3.3 Appreciation of the relationships and responsibility between science, society and the environment

As mentioned earlier, science occurs in a society. Hull (1995:31) posits that science is relevant to people and has implications for people and all nations. "Science is important to us all", say Trowbridge and Bybee (1990:36). The world depends on Science and Technology for their dominant forces in civilization. Science has brought hope for a better world through technological innovations, as well as a recipe for disaster, in the form of nuclear warfare, chemical warfare and air pollution due to industrialization (the ozone layer is fading). Science can never be divorced from society; hence one of its learning outcomes - to be discussed later - is demonstration of an understanding of the interrelationships between Science, Technology, society and the environment.

The NCS Policy Document (DoE, 2002:5) demands that teaching and learning of the Natural Sciences should promote and foster the understanding of:

- science as a human activity;
- the history of science;
- the relationship between Natural Science and other learning areas;
- the contribution of Science to society and environment;
- responsibility to ourselves, society and the environment; and
- the consequences of decisions that involve ethical issues.

Figure 3.1 summarizes aptly all that has been discussed above. Hull (1995:2) illustrates this in the form of a diagram.

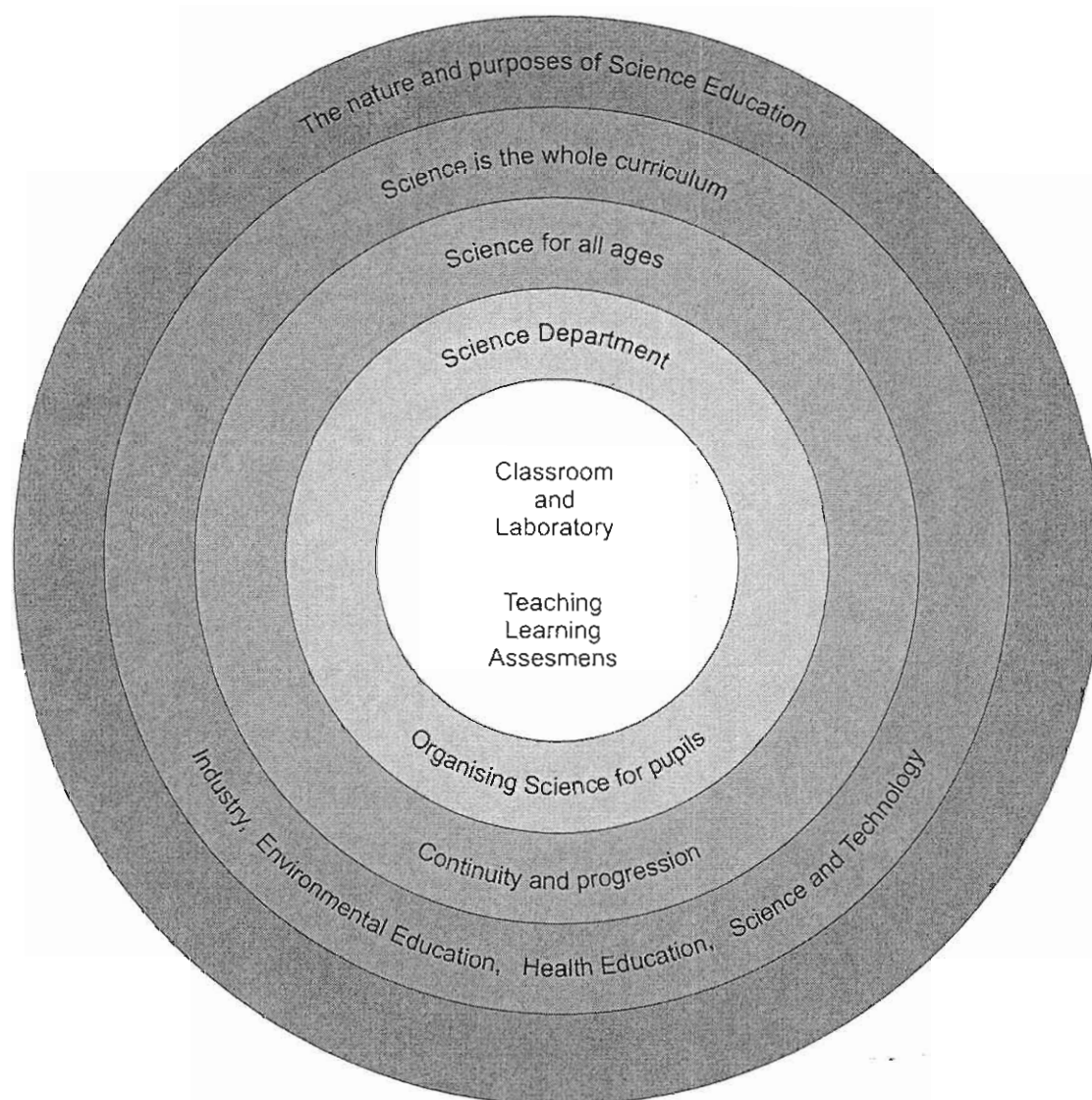


Figure 3.1: Nature and purposes of science

3.3.4 The outcomes for teaching the Natural Sciences

3.3.4.1 Critical and developmental outcomes

The critical and developmental outcomes are the same in all grades and all learning areas. These form the purpose of schooling. They are a list of outcomes derived from the South African Constitution. As mentioned earlier, the current South African Curriculum is based heavily upon the values spelled out in the Constitution (1996b). The aims of the Constitution are to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;
- improve the quality of life of all citizens and free the potential of each person;
- lay the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected; and to
- build a united and democratic South Africa, able to take its rightful place as a sovereign state in the family of nations.

The National Education Policy (1996a) enshrines these values and is reflected in all the components of the National Curriculum Statement. The critical and developmental outcomes therefore describe the kind of citizen this education system of South Africa is expected to produce. Here follows a list of both critical and developmental outcomes.

Critical outcomes require learners who can:

- identify and solve problems and make decisions, using critical and creative thinking;
- work effectively with others as members of a team, group, organization and community;
- organize and manage themselves and their activities responsibly and effectively;
- collect, analyze, organize and critically evaluate information;
- communicate effectively, using visual, symbolic and language skills in various modes;
- use science and technology effectively and critically, showing responsibility towards the environment and the health of others; and

- demonstrate an understanding of the world as a set of related systems by recognizing that problem-solving contexts do not exist in isolation.

The developmental outcomes direct education to model learners to be able to:

- reflect on and explore a variety of strategies to learn more effectively;
- participate as responsible citizens in the life of local, national and global communities;
- be culturally and aesthetically sensitive across a range of social contexts; and
- explore education and career opportunities.

It is important to include these outcomes when introducing the curriculum because teachers have to bear them in mind when planning their lessons.

3.3.4.2 Learning outcomes

Learning outcomes differ per learning area. The Natural Sciences have only three learning outcomes (DoE, 2002:6). Learning outcomes are derived from critical and developmental outcomes. Learning outcomes describe what knowledge, information, skills, attitudes and values learners should know, have and do at the end of each grade. They should also ensure progression and integration of the concepts above. They prescribe neither context nor methods of teaching.

The three learning outcomes for the Natural Sciences are:

Scientific investigation

The learner will be able to act confidently on curiosity about natural phenomena and to investigate relationships and solve problems in scientific, technological and environmental contexts.

Constructing science knowledge

The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

Science, society and the environment

The learner will be able to demonstrate an understanding of the interrelationships between science and the environment.

It was indicated earlier that learning outcomes are derived from critical outcomes.

The table that follows, attempts to put this statement into perspective.

Table 3.1: The interrelatedness of learning and critical outcomes

LEARNING OUTCOMES	CRITICAL OUTCOMES
LO1 Scientific investigation	CO1 Identify and solve problems and make decisions, using critical thinking. CO3 Organize and manage themselves and their activities responsibly. CO4 Collect, analyse, organize and critically evaluate information
LO2 Constructing science knowledge	CO5 Communicate effectively using visual, symbolic or language skills. CO2 Work effectively with others as members of a team.

LO2 Science society and the environment	CO6 Use science and technology effectively and critically, showing responsibility towards environment and health of others. CO7 Demonstrate an understanding of the world
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Learning outcomes are also very fundamental to assessment standards. The relationship between the two will be illustrated in the section dealing with assessment standards (*cf* 3.3.5).

Since teaching and learning in South Africa is Outcomes-Based, it is essential at this point to unpack the three learning outcomes so as to understand them fully for future reference.

Learning outcome 1: Scientific investigation

The learner will be able to act confidently on curiosity about natural phenomena and investigate relationships and solve problems in scientific, technological and environmental contexts.

The key words here are curiosity, investigate, solve problems. Curiosity requires one to explore in order to find answers to a puzzle. To do this one investigates possibilities by using the process skills listed earlier (*cf* 3.3.3.1). Problem-solving is a life-long exercise which also calls for application of problem-solving skills. The policy demands that learners should engage in at least four kinds of practical problem-solving:

- The problem of making. Learners are curious to know HOW they can make their own scientific or technological gadgets such as solar heaters, electric water fountains, mini volcanoes, etc.
- The problems of measuring, observing and surveying. This involves studying phenomena in their natural habitat, their behaviour, habits, etc. For example, finding out HOW rabbits reproduce.

- The problems of comparing. Learners investigate the relationship of substances. They could do this by comparing the reaction of sodium, lithium, magnesium and potassium in water and observe which one reacts the fastest.
- The problems of determining the effect of certain factors. Learners find out what happens if something is done to anything, that is, they look for cause and effect. Example "What would happen if I put a plant in a place where there is no light?"

All these problems can be addressed only if the learner has conceptual knowledge, process skills of scientific investigations and creativity.

Learning outcome 2: Constructing science knowledge

The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

This requires learners to construct science knowledge by being able to get a variety of sources and organize, analyse and synthesize them. In this manner, new information is processed and added to existing ones. Process skills outlined earlier in this chapter are required for this process (*cf* 3.3.3.1).

Learning outcome 3: Science, society and environment

The learner will be able to demonstrate an understanding of the interrelationship between science and technology, society and the environment.

This is a very complex, yet important outcome. Complex, because the concept of a science curriculum which takes cognizance of values, world views and indigenous knowledge is a novelty; important, because it is this outcome which really depicts the type of citizen the democratic South Africa envisages. The National Curriculum Statement complies through this learning outcome specifically, with the call that was made by the Addis Ababa Conference of African States on the development of education in 1961. The statement made by the conference went as follows:

African education authorities should revise and reform the content of education in the areas of curriculum, text book and methods, so as to take account of the African environment, child development, cultural heritage and the demands of technological progress and economic development, especially industrialisation (Naidoo & Salvage, 1998:2).

The White Paper on Science and Technology (SA, 1995:10) suggests that:

Education should adopt a problem-solving approach

Education and Training in an innovative society should not trap people within constraining specialties, but enable them to participate and adopt a problem-solving approach to social and economic issues within and across discipline boundaries.

Learning outcome three endeavours to ascertain that traditional practices of scientists, conforming to fact and theory and particular methods and certain standards, are curtailed (Edwards *et al.*, 1993:6). These authors claim that, since there is acknowledgement that science is a human activity driven by societal values and aspirations, different societies might have different interpretations, definitions, world views and priorities concerning science (Edwards *et al.*, 1993:13-14).

The NCS has given guidelines to at least four headings under which this learning outcome should be examined:

Education should help people to become problem-solvers

As the purpose of education is to prepare for adulthood, learners will be adults in the future. They should therefore be skilled in problem-solving because they will encounter many problems in societies in which they live. They should be creative thinkers and innovators. They should use their knowledge of science to look for ethical alternatives for solving problems.

Traditional technologies may reflect peoples' wisdom and experience

Traditional knowledge and wisdom of the African people has been lost through colonialization and technological innovations. Traditional technologies depict and inform on people's wisdom and experiences. As Naidoo and Salvage (1998:26) state, researchers agree that technology-making has always existed in Africa.

Many of these experiences and of this wisdom have been lost in past decades when Africans were not allowed to be part of curriculum planning. Learning outcome three implies that indigenous and traditional knowledge systems should be part of what learners should know.

The scientific and technological choices people make reflect their values

This learning outcome calls upon learners to acquire an understanding of how values are influenced. Modern societies are faced with technological and scientific issues about which they have to make decisions. Issues such as human cloning, genetically produced crops, consequences of nuclear energy, the decreasing ozone layer, etc., demand that people have knowledge of science before entering any debate on these issues (Alsop & Hicks, 2001:28). If one needs to purchase a car, one has to do some research about the car, its petrol consumption, its durability and many more technical issues. To do this, one needs to have basic knowledge of science.

Different world views are usually present in the Science classroom

According to Edwards *et al.* (1993:5), at any given time in a teaching/learning situation, teachers have an influence on learners. The teachers' world view and learners' experiences collectively bring different world views into a Science classroom. These are often drawn from one's environment. Science learning helps explain and shape some of these and also dispels some misconceptions. Different world views create interesting challenges to both teachers and learners. They feed innovative ideas which lead to new discoveries. The NCS aims at making learners aware that indigenous knowledge has a role to play in Science.

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National Curriculum Statement policy document for the Natural Sciences (DoE, 2002:45-59). The following tables indicate the assessment standards for Grade nine only and also provide examples of the relationship between a learning outcome and an assessment standard.

Table 3.3: Example of relationship between learning outcomes and assessment standards

LEARNING OUTCOME 1	ASSESSMENT STANDARDS GRADE 9
Scientific investigation. The learner will be able to act confidently on curiosity about natural phenomena and to investigate relationships and solve problems in scientific technological and environmental contexts.	We know this when a learner: plans investigations by planning procedures to test predictions or hypotheses with control of an interfering variable.
	Achievement is evident when the learner: - expresses a question in a testable form; - identifies an interfering variable and explains how it will be taken into account; - pilot-tests an interview schedule before doing a survey, etc.

From this example, it becomes clear that assessment standards guide the teacher to decide what activities would be best for optimal achievement of any learning outcome.

A summary of assessment standards for each learning outcome follows.

Table 3.4: A summary of the assessment standards for each learning outcome

LEARNING OUTCOME	ASSESSMENT STANDARDS
LO1 Scientific investigation	• Planning investigations • Conducting investigations and collecting data • Evaluating data and communicating findings
LO2 Constructing science knowledge	• Recalling meaningful information when needed • Categorising information to reduce complexity and look for patterns • Interpreting information • Applying knowledge to problems that are not taught explicitly
LO3 Science society and the environment	• Understanding science as a human endeavour in cultural contexts • Understanding sustainable use of the earth's resources

The following paragraphs will attempt to relate the teaching methods and styles discussed in Chapter two (*cf* 2.3.2.4) on how best to implement the curriculum, taking cognizance of OBE principles, purpose of sciences, critical and developmental outcomes, learning outcomes and the philosophical/theoretical foundations of learning theories, as well as learning styles.

3.4 TEACHING METHODS FOR TEACHING THE NATURAL SCIENCES

Before a decision can be taken on whether there is a best method or methods of teaching the Natural Sciences, a close look at the profile of the cognitive development of the targeted learner has to be taken. This study focuses on senior phase learners who are on the average, 13-15 years of age. These learners are, according to Piaget's Theory, at the formal operational stage of their cognitive development (*cf* 2.2.5.1). They are said to be able to:

- conceptualize and hypothesize;
- think more orderly and systematically;
- apply logical thinking in problem-solving; and
- concentrate more on possibilities than on realities.

Carin and Sund (1989:38) add a few capabilities to these target learners. They can:

- evaluate thinking processes, think about thinking;
- control variables;
- do abstract, non-concrete conceptual thinking;
- question ethics; and
- do ratios, proportions and combinational logic.

Bruner places these learners at the symbolic stage (*cf* 2.2.5.3) where they:

- understand symbols;
- understand scientific notations and figures; and
- can absorb quantities of information of varying types.

Learning about science is, as indicated earlier, constructing meaning and making sense out of the world. Of the learning theories that were discussed in Chapter two, namely Constructivism, is one of the most favoured and preferred for science teaching (*cf* 2.2.6.2).

Constructivism views learning as an interaction between the learners and their environment. For any learning to occur during this interaction, prior knowledge forms the basis of construction of meaning (Alsop & Hicks, 2001:38). These two authors represent this process diagrammatically as follows:

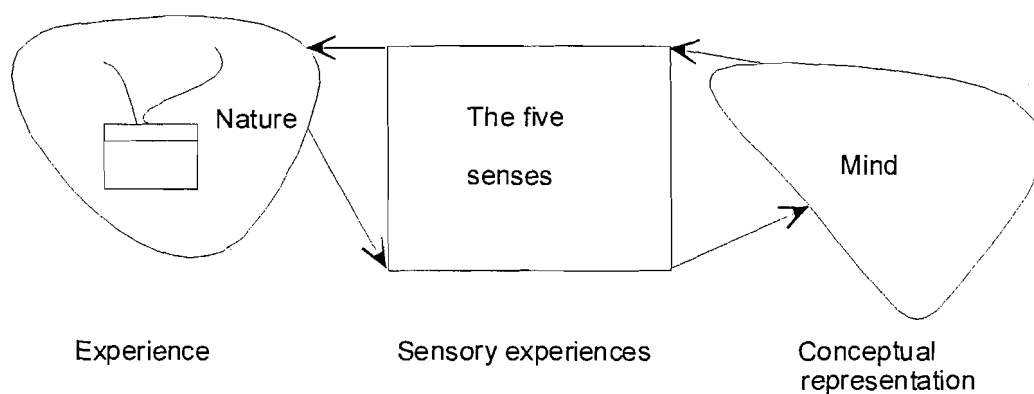


Figure 3.2: A constructivist view of learning

Prior knowledge forms what was referred to as schemes. Science concepts don't always exist in nature, as they are coined by humans as labels for natural phenomena. They thus become tricky to teach, as the learner has nothing to retrieve from long-term memory as anchorage for new concepts (Edwards *et al.*, 1993:121). This complicates the teaching of science as these ideas go beyond human senses and learners do not have any experience in concept construction (Edwards *et al.*, 1993:116).

Teaching the Natural Sciences no longer assumes that learners have no ideas of their own. It acknowledges that learners come into the science class with ideas, whether wrong or right, and what these ideas are is for the teacher to establish. It is also a fact that, despite the common level of cognitive development these learners share, they do not have the same world views, learning styles, intelligence or zones of proximal development. It is for this reason that science teachers are urged to establish all the above factors before planning a science lesson. Driver, as quoted by Alsop and Hicks (2001:47), proposes this constructivist teaching approach. This is a five-phased approach and it is represented by the diagram below.

Phase

Overview

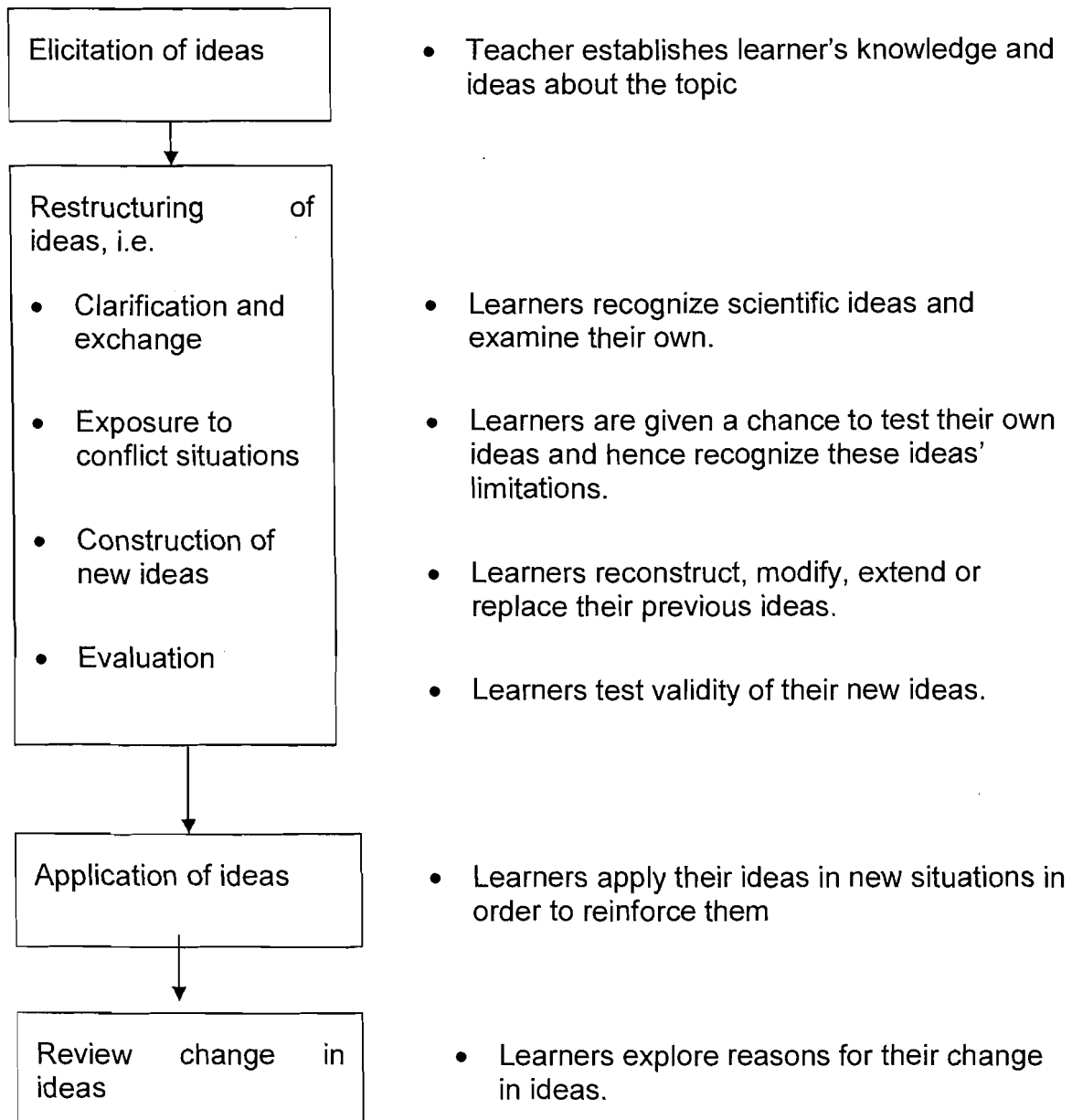


Figure 3.3: Five-phased approach to constructivist learning

It is because of all the factors outlined above that it becomes almost impossible to give an answer to the question on what the best method for teaching science is. Teachers have to approach every science lesson with more than one teaching method. Carin and Sund (1989:88) aptly summarize the complexity of science teaching as follows:

“Some of the variables you must consider (when teaching science) involve children’s unique learning styles, your teaching style, physical classroom environment, community and school administration priorities etc. Because of these variables, you quickly see that there is no best way to teach science to all children.”

Having said this, the researcher intends to make a suggestion regarding teaching methods that are believed to be the most relevant, appropriate and effective in assisting the learner to achieve competency in the required three learning outcomes and assessment standards in the Natural Sciences. The teaching methods will be those that endeavour to engage the learner’s metacognitive skills, as these are predominantly required in learning science and are favoured by learners whose preferred learning style is thinking. This implies the application of Indirect Instruction, Independent Instruction and Interactive Instruction (*cf* 2.3.2.2, 2.3.2.3, 2.3.2.4).

Traditional approaches such as Memory Psychology and Behaviourism as discussed in the previous chapter (*cf* 2.2.1 and 2.2.3), will also be used, albeit minimally. These approaches are essential during the introduction of a new concept when the teacher explains instructions and procedures, and during the wrapping up and consolidation of a lesson. They are also important for learners who prefer learning through sensing, feeling and whatching.

Choosing a teaching method or style has to be directed, mainly, by the type of learners the teacher has (*cf* 2.4). It is futile to teach a divergent learner using methods suitable for a convergent learner. All teaching methods and styles as discussed in 2.3 and 2.4 are applicable for teaching the Natural Sciences. Each method and style addresses a particular learning style. The following is a short indication of the teaching method that could be used for learners with a specific learning style.

Table 3.5 Learning styles and suitable teaching method

Teaching method/strategies	Learning style/learner type
1 <u>Direct Instruction</u> Lectures Demonstrations	Sensors, feelers and watchers
2 <u>Indirect Instruction</u> Discussions Group projects Field trips and site visits Experimentation Case studies Oral presentations.	Auditory, linguistic, logical/ mathematical, spatial, innovative, dynamic, divergent, assimilatory, interpersonal, common- sense learners
3 <u>Independent Instruction</u> Assignments/homework Problem-solving. Crossword puzzles Research projects	Doers, thinkers, analytics, intrapersonal, tactile/kinesthetic.
4 <u>Interactive Instruction</u> Co-operative learning (all techniques in 2.3.2.4).	Interpersonal, auditory, doers, visual, creative, verbal/linguistic, logical/mathematical, convergent, divergers, assimilators, analytics, accommodators, thinkers, dynamic, creative, tactile/kinesthic innovative.

The last teaching method, co-operative learning, is the method advocated for by the NCS for Natural Sciences teaching. It becomes obvious from the above analysis why it is preferred to others: it accommodates a large percentage of the learning styles. Experimentation, projects and group work

are also methods frequently employed in the teaching of the Natural Sciences (Ferreira, 1994:12).

3.5 ASSESSMENT STRATEGIES APPROPRIATE FOR THE NATURAL SCIENCES

Curriculum 2005 prescribes seven forms of assessment that are suitable and most effective for Natural Sciences assessment in the senior phase. These are compulsory. They are investigations, projects, assignments, tests/examinations, presentations, performances and translation tasks (DoE, 2003:33).

3.5.1 Investigations

These are practical tasks that are designed to collect, analyse and interpret data in order to solve problems, test hypotheses and answer questions (DoE, 2003:34). At least three of these have to be performed per year to form part of the learners' assessment portfolio. These can be either group or individual tasks.

3.5.2 Projects

These are practical tasks done independently by learners to find out something new. The fundamental aim of projects is to develop scientific knowledge and apply it to day-to-day problem-solving (DoE, 2002:34). Only one of these is required per year. These can be either group or individual tasks.

3.5.3 Assignments

These are tasks given to learners to do either at home or in class. They are often used to consolidate the lesson or concept. They are written as problem-solving exercises (DoE, 2003:44).

3.5.4 Tests/examinations (DoE, 2003:48)

These tasks are used to recall information accumulated over a long period. They are used to test a variety of specific outcomes. Five written short tests and one written examination are required. One of the tests must be practical work. These are individual tasks

3.5.5 Presentations

These are oral presentations by learners to learners. The oral presentation is supported by posters, models or any display of a diagram or pictures (DoE, 2003:52). They can be carried out individually or in groups. A minimum of one of these per year is required.

3.5.6 Performances

In performances, learners are given a problem which they have to solve by role-playing or acting out the processes leading to the solution (DoE, 2003:53). This is group work only one is assessed per year.

3.5.7 Translation tasks

This is changing information from one form to another, for example, changing information given in words to graphs or tables, or changing pictures to words (DoE, 2003:57).

3.6 SUMMARY

The discussions throughout this chapter indicate clearly that, for effective learning to occur, teachers have to utilize a variety of teaching strategies, styles and methods. In this way, teachers would ensure that learners' different learning styles and personalities are accommodated. Teachers need to adopt teaching strategies and methods, as well as assessment techniques and strategies that encourage and enhance the acquisition of higher-order skills and accommodate learner diversity. Emphasis should be placed on those teaching skills that comply with policy requirements and OBE

approaches. This will ensure maximum involvement of learners in their learning process.

3.7 CONCLUSION

This chapter focussed on linking the generic discussion on learning theories, teaching styles, learning style and assessment strategies with teaching the Natural Sciences.

The next chapter will provide an overview of the empirical study conducted.

CHAPTER FOUR

EMPIRICAL RESEARCH DESIGN

4.1 INTRODUCTION

The previous chapter attempted to link teaching methods, teaching styles, and assessment methods and techniques to the different learning styles in a classroom situation. Teaching methods and assessment techniques most relevant to the teaching and learning of the Natural Sciences were also identified.

The main purpose of this chapter is to give a comprehensive explanation of the:

- aims of the research;
- research methodology;
- population and sample selection;
- data collection;
- data analysis;
- ethical considerations; and
- limitations of the study.

4.2 AIMS OF THE RESEARCH

As indicated in the opening chapter of this study, the overall aim of this study is to improve the effectiveness of teaching and learning of the Natural Sciences by linking teaching intentions and assessment with diverse learning styles. This broad aim was operationalized as follows:

- by determining how well learning style diversity is addressed in the teaching of the Natural Sciences as secondary school level;
- by determining whether teachers are skilled enough to address learning style diversity in the teaching of the Natural Sciences as secondary school level; and
- by developing a programme in the form of guidelines in which teaching intentions and learning outcomes are linked with diverse learning styles.

4.3 RESEARCH METHODOLOGY

To answer the question of the choice of the research methodology, the researcher established what kind of data to be gathered. Data can either be quantitative (in the form of numbers), or qualitative (perceptions or opinions) or triangulation.

Another important aspect that needed consideration was the role of the researcher. Would the researcher be an external observer or would the researcher be looking through a lens from the inside out?

Examining the role of the researcher would define interest in the objective (quantitative) or subjective (qualitative) style of research to be followed, an integration of both styles.

As the researcher decided to be an external observer whose intent it was to establish and confirm relationships and to develop generalizations that contribute to theory, a quantitative approach was chosen (Leedy & Ormrod, 2005:95)

4.3.1 Quantitative research

Quantitative research is structured around objectivity. Central to this style of research is the survey. Surveys may be administered in the form of structured and semi-structured interviews or questionnaires. Standardized tests may also be used (De Vos, 2002:137-138; Leedy & Ormrod, 2005:179). Survey research involves acquiring information (opinions, attitudes, experiences)

about one or more groups of people by asking them questions and tabulating their answers (Leedy & Ormrod, 2005:183). Survey research typically employs a face-to-face interview, a telephone interview, or a written questionnaire. For this particular study survey research by means of questionnaires was utilized to collect numerical data on the analyzed ideas and perceptions elicited by the questionnaires.

An important aspect that was considered before the research was conducted was whether the chosen research design could be regarded as valid for this type of research.

4.3.2 Validity

The **internal** validity of the design was supported by the fact that it would allow the researcher to draw accurate conclusions. The researcher was convinced that the conclusions to be drawn could be warranted from the data collected (Leedy & Ormrod, 2005:97).

The **external** validity of the design was enhanced by the fact that the research would be conducted in a real-life setting (Leedy & Ormrod, 2005:99).

4.4 DATA-GATHERING INSTRUMENTS

Although there is a myriad of data-gathering instruments for conducting quantitative research, the researcher opted for questionnaires.

4.4.1 Questionnaires

Questionnaires are often used to make data collection more efficient and standardized (Saslow, 1982:14). They are frequently used to provide the main source of data in primary research. They provide invaluable descriptive data about individuals or a group. They are concerned with description and measurement (Clarke, 1999:68).

There are three types of questionnaires, namely the self-administered, the investigator-administered and psychological tests (Mitchell & Jolley, 2001:472). For the purpose of this study, the first two options were chosen.

4.4.1.1 Self-administered questionnaires

This option was chosen for conducting the pilot study. Respondents fill in the questionnaires individually in the absence of the researcher (Mitchell & Jolley, 2001:478). Questionnaires are either sent or delivered to the respondents and collected on a later date by the researcher. The self-administered questionnaires have the following advantages and disadvantage.

Table 4.1: Advantages and disadvantages of self-administered questionnaires

ADVANTAGES	DISADVANTAGES
• They are easily distributed to a large number of people. • They allow for anonymity. • They are relatively a cheaper way to collect data.	• There is usually a low return-rate from respondents. • Problems such as ambiguity cannot be resolved because researcher and respondent do not interact.

4.4.1.2 Investigator-administered questionnaires

This option was chosen for the actual research. These are responded to in the presence of the researcher. The researcher presents and administers the questionnaires and immediately collects them afterwards (Mitchell & Jolley, 2001:478). This type of questionnaire has the following advantages and disadvantages:

Table 4.2: Advantages and disadvantages of investigator-administered questionnaires (Mitchell & Jolley, 2001:478)

ADVANTAGES	DISADVANTAGES
- Investigator can clarify questions for respondents. - Investigator's presence stimulates participants to respond, yielding higher responses.	- Investigator's presence reduces anonymity. - Because of the reduced anonymity, participants might not be honest in their responses.

During the pilot study the self-administered questionnaire option was used. The problem of low and delayed returns was experienced. It is for this reason that the researcher decided to utilize the investigator-administered option during the actual implementation of the survey.

4.4.1.3 Aims of the questionnaires

As Clarke (1999:68) aptly puts it, questionnaires have a specific function: to measure. For this particular research, questionnaires were developed for teachers and learners. The aim of the questionnaires in this study was to identify and measure the magnitude of areas that need improvement in the teaching and learning of the Natural Sciences, specifically in Grade nine (senior phase). The focal point in this case was to determine whether teaching methods, teaching styles and assessment strategies accommodate diverse learning styles.

4.4.1.4 Structure of the questionnaires

Based on the literature review, the questionnaires were developed to determine how well teachers address diverse learning styles in the teaching of the Natural Sciences in Grade 9 (senior phase).

Two questionnaires were developed by the researcher: one for the teachers and another for the learners. The same questions put to the teachers were modified to suit the learners. This was done to counter-check teachers' and learners' responses for accuracy and credibility.

The questionnaires to educators and learners were categorized into six sections (*cf* Appendix A & B).

The six sections to both educators and learners were similar - they required the same information from both. The sections were divided as follows:

- Section 1 called for biographical information. In this section only learners were requested to also indicate their achievement in the Natural Sciences.
- Section 2 identified which teaching style was predominantly used.
- Section 3 sought to find out which teaching methods were commonly used.
- Section 4 established the frequency of accommodating specific learning styles during the teaching of the Natural Sciences.

Section 5 established the frequency of use of different assessment strategies to accommodate diverse learning styles.

- Section 6 identified problems teachers and learners encountered during the teaching of the Natural Sciences.

Based on the shortcomings identified from the responses, a teaching and learning programme in the form of guidelines was developed to assist teachers to address learning style diversity in the Natural Sciences in Grade 9 (senior phase).

4.5 THE TEACHING AND LEARNING PROGRAMME FOR THE NATURAL SCIENCES

The programme is structured as follows:

The two chosen strands (*cf* 3.3.1), namely energy and change and matter and materials are sub-divided into different topics. For all the various topics learning outcomes and assessment standards are identified. To accommodate all diverse learner needs in the achievement of these outcomes, the programme offers suggestions in the form of learning activities on how to combine teaching styles, teaching methods and assessment strategies for all diverse learner needs.

4.6 PILOT STUDY

A pilot study is the administering of part of the research on a very limited scale to check whether it will work in practice. Saslow (1982:87) and Mitchell and Jolley (2001:127) admonish that a study should be tried out on a few participants before the actual study is conducted. They posit that, if this is not done, discrepancies in actual and expected responses might be detected too late. It is for this reason that the questionnaires in this study were piloted.

Subsequently, a sample of 25 educators and 50 learners from the target population (who were not part of the actual research sample) were identified for the pilot administration of the questionnaire regarding its qualities of measurement and appropriateness and to review it for clarity. There was a full return from educators, but only 37 returns from learners. The outcome of the pilot study was an indicator of whether the questionnaire was a reliable and valid instrument to use. The Statistical Consulting Services of the North-West University, Vaal Triangle Campus was utilized in determining the validity and reliability of the data collection instrument.

4.6.1 Reliability of the data collection instrument

A Cronbach Alpha coefficient of reliability indicated a coefficient of 0,805. A reliability coefficient of 0.80 or higher is acceptable in most Social Sciences application (Statistical Consulting Services, 2005). The data collection instrument thus complied with reliability criteria.

4.6.2 Validity of the data collection instrument

Validity was arrived at by considering both content validity and construct validity.

Content validity is the extent to which a data collection instrument is a representative sample of the content area being measured. The items or questions should reflect the various parts of the content domain in appropriate portions (De Vos, 2002:167; Leedy & Ormrod, 2005:92). The content validity for the data collection instrument used in the research is supported by the fact that the specific items in the questionnaire were constructed strictly according to the essential components for the content domain, namely, an effective teaching and learning situation in the Natural Sciences. This implied a close look at the choice of teaching styles, teaching methods, learning styles and assessment strategies in order to meet diverse learner needs.

Construct validity is the extent to which an instrument measures a characteristic that cannot be directly observed, but must be inferred (De Vos, 2002:167; Leedy & Ormrod, 2005:92). The data collection instrument definitely measures the construct in question, namely, an effective teaching and learning situation in the Natural Sciences. It focuses on all the important components of the construct (effective teaching and learning), namely the choice of teaching styles, teaching methods, learning styles and assessment strategies.

The researcher was of the opinion that the instruments' validity and reliability were beyond reproach and could be implemented with confidence and with full knowledge that the outcome of the findings would provide insight into the practices of the educators at issue.

4.7 THE POPULATION AND SAMPLE

4.7.1 The population

The population of this study comprised all the 62 public secondary schools in the Lejweleputswa district of Free State province. All Grade 9 learners in

these schools, as well as all Grade 9 teachers of the Natural Sciences teachers were the possible participants in this study.

4.7.2 Sample

Due to time and financial constraints only six schools were randomly selected from the sixty-two. By means of **systematic sampling** the six schools were selected according to a predetermined sequence. A list of units that lied within the population of interest was compiled and every 10th unit on the list was selected (Leedy & Ormrod, 2005:203).

All the teachers and learners of the Natural Sciences in Grade nine at the six schools formed the sample. The total number of teachers was 60 and the total number of learners was 711.

Grade nines were a preferred group for this study because they are in the exit grade of the General Education and Training Band and the National Curriculum Statement has very specific instructions about what summative assessment procedures are to be effected for these learners. Since it is common practice for educators to exert themselves regarding teaching, learning and assessment when dealing with externally assessed grades, it was expected that the teachers of the Natural Sciences who formed the sample of this study, would follow the trend and therefore provide an effective teaching and learning situation for the purpose of the research.

4.8 DATA ANALYSIS

Descriptive statistics were utilized to analyse the data obtained from the questionnaires.

4.8.1 Descriptive statistics

Descriptive statistics summarize the general nature of the data obtained – for instance how certain measured characteristics appear to be “on the average,” how much variability exists among different pieces of data and how closely two or more characteristics are interrelated (Leedy & Ormrod, 2005:30). For the purpose of the research frequencies, means and percentages were

calculated for the various categories in the questionnaire. Data is presented in tables and graphs for easier interpretation.

4.9 ETHICAL CONSIDERATIONS

According to Clarke (1999:83), there are bound to be ethical issues to consider whenever inquiry is made of participants. As dictated by the principles of ethics, participants, have the right to know what will happen in the study. They also have the right to decline participation in the study should they feel uncomfortable and they have the right to anonymity (Mitchell & Jolley, 2001:24). The researchers have certain responsibilities. They have to preempt possible risks to participants and guard against these so as not to expose participants to them.

Mitchell and Jolley (2001:24) have identified some ethics that researchers have to observe, particularly where human participants are involved. These are:

- Participants should volunteer to be in the study.
- Participants should have an idea of what their role is in the study. They should be well-informed about anything they might perceive as unpleasant.
- Participants should be told that they have the liberty to withdraw from the study at any time, should they find it unpleasant.
- Researchers should treat participant's responses with confidentiality.
- Researchers have to ensure that co-researchers also observe these ethics.
- Researchers should anticipate possible risks to participants and counteract accordingly.
- Researchers should search for signs of harm to participants at the end of the study and undo the harm, if any.

- Researchers should explain the purpose of the study and be prepared to answer any questions.
- Researchers should get approval from relevant authorities.

All these ethical guidelines, as outlined above, were followed by the researcher. Furthermore, the following was done:

- A letter requesting permission from the Provincial Department of Education, Free State Province was written and permission was granted in writing (*cf* Appendix C).
- Principals and teachers, as well as learners of sample schools were addressed and their roles and the purpose of the study explained in detail.
- Participants were assured verbally and in writing of anonymity and confidentiality.
- Participants were also informed that they should participate voluntarily in the study.

4.10 LIMITATIONS OF THE STUDY

There are limitations in all educational research studies. These may vary from a researcher's over-involvement in a case study to rigorous adherence to objectivity in a survey.

One of the major limitations of this study is the fact that only a quantitative research approach was utilized. After analyzing teachers' survey responses during the pilot study, it became clear that certain trends emerged, requiring further investigation into educators' perceptions of the teaching and learning situations. This could have been achieved by integrating qualitative strategies like interviews and classroom observations into the research approach. In this study, only one technique was used, namely questionnaires. This could affect the validity of the study unlike where a variety of techniques are used as a means of validating the information.

Another limitation of the study was the size and nature of the sample. The study was conducted in only one of the nine provinces of South Africa and that limits the findings. The limited number of participants therefore means that the results of this study cannot be generalized.

4.11 CONCLUSION

This chapter outlined the empirical design, albeit briefly. The main purpose was to put the reader into a clear frame of mind concerning the procedures the researcher followed in conducting this study. The next chapter will focus on actually applying techniques mentioned in analyzing and interpreting the data.

CHAPTER FIVE

DATA ANALYSIS AND INTERPRETATION OF THE RESULTS OF THE EMPIRICAL STUDY

5.1 INTRODUCTION

The preceding chapter was dedicated to outlining the process followed when collecting the data for this study. This chapter attempts to make sense of the data by analyzing and interpreting it and linking the results to the core of the study which is to establish whether the teaching and assessment of the Natural Sciences, as currently done, takes cognizance of learners' learning styles and therefore achieves the envisaged learning outcomes. This study further attempts to produce guidelines for the teachers on how to use teaching strategies and methods, as well as assessment strategies, to accommodate learners' learning styles in the teaching of the Natural Sciences.

A 100% return was realized for the learner questionnaires (711 responses). Out of the 60 questionnaires that were given to teachers, 54 were returned.

The questionnaires for both learners and teachers were processed by the Statistical Consultation Services of the North-West University. Responses were entered as frequencies and converted to percentages to make them easily comparable and convenient to display as graphs. Percentages are also relatively easy to interpret.

Through the analysis of the results obtained from the questionnaires certain facts were unearthed from which deductions could be made and inferences be drawn. As findings are outlined, both deductions and inferences drawn from them are highlighted.

The following tables display the results obtained through this empirical research. The responses from teachers and learners are reported together to

make the comparison between the two groups easier. No responses are indicated as “missing” responses.

5.2 DATA ANALYSIS AND INTERPRETATIONS OF FINDINGS

5.2.1 Demographic information

5.2.1.1 Teachers

Information about teachers’ qualifications and their years of experience as teachers of the Natural Sciences was sought. This was intended to provide insight regarding the type of teacher who forms part of this study. Information about learners would serve the same purpose of giving an overall picture of the learners representing the sample of this study.

Table 5.1: Teachers’ highest academic qualifications

	Frequency	Percentage
Grade 10	0	0
Grade 12	28	51.9
Bachelor of Arts degree	14	25.9
Honours degree	8	14.8
Masters degree	0	0
Missing	4	7.4
Total	54	100

This information can be represented graphically as follows:

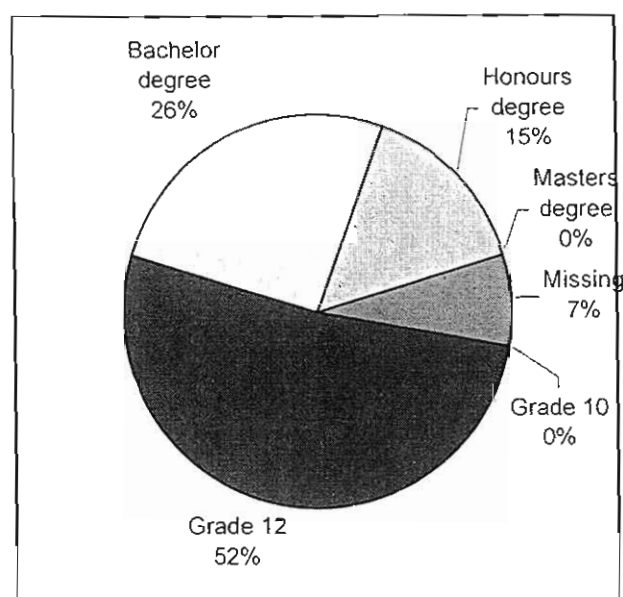


Figure 5.1: Teachers' highest academic qualifications

A large number of teachers (51.9%) have only Grade 12 as their highest academic qualifications.

Almost half of the respondents have only Grade 12 as their highest academic qualification. This fact has a direct adverse influence on the teachers' content knowledge of the Natural Sciences. It can be inferred that these teachers' knowledge of the Natural Science content is slightly above Grade 12 level. This could lead to a teacher's lack of confidence in the subject matter. Outcomes- Based Education requires a teacher to have full control of the learning area content in order to facilitate and guide learners effectively (*cf* 1.1).

Table 5.2: Teacher's highest professional qualifications

	Frequency	Percentage
One year diploma/Certificate	2	3.7
Two year diploma/Certificate	2	3.7
Three year diploma/Certificate	24	44.4
Four year diploma	12	22.2
Post-graduate diploma	11	20.4
Missing	3	5.6
Total	54	100

This information can be represented graphically as follows:

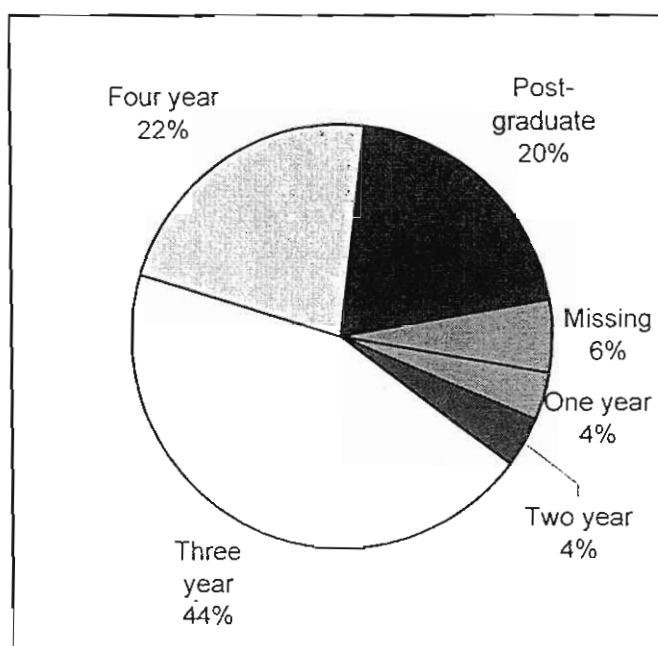


Figure 5.2: Teachers' highest professional qualifications

The total number of one year, two year and three year diploma holders (28) corresponds directly with the number of teachers who have Grade 12 as their highest academic qualification.

Most teachers have a three year diploma. This professional qualification is the minimum requirement for anybody who aspires to be a teacher in South Africa. The content knowledge that one has is just sufficient for the senior phase level. The assumption that the researcher makes is that, of the 14 teachers who hold a Bachelor's degree, eleven augmented this with a post graduate diploma, which qualifies them to be competent teachers. Four-year diploma holders (22.2%) are, in the researcher's opinion, trained most appropriately to deal with the learners at senior phase level, provided they majored in the Natural Sciences.

Table 5.3: Teachers' experience in teaching the Natural Sciences

	Frequency	Percentage
1-5 yrs	24	43
6-10 yrs	16	30
11-15 yrs	7	13
16-20 yrs	3	6
+ 20 yrs	3	6
Missing	1	2
Total	54	100

This information can be represented graphically as follows:

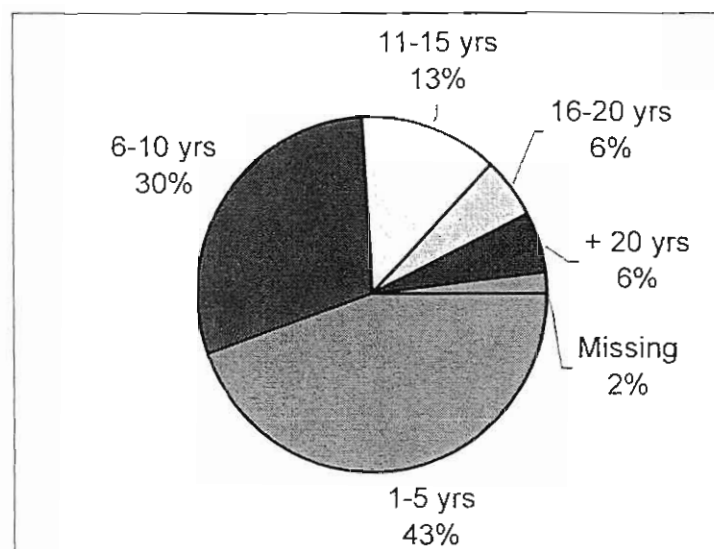


Figure 5.3: Teachers' experience in teaching the Natural Sciences

A large number of teachers have the minimum years of experience in teaching the Natural Sciences. Most of the teachers in this study have only taught science for a period of one to five years. This is a short period to have acquired competency in teaching the Natural Sciences. This shortcoming could be compounded by the many innovations that have been occurring in the curriculum of the South African Department of Education (*cf* 1.1).

The 29.6 % who have taught the Natural Sciences for six to ten years are not more competent than the previous group. It can be assumed that any teacher

who has less than ten years experience in teaching the Natural Sciences with Grade 12 as his/her highest academic qualification is cause for concern.

Table 5.4: Teachers' experience in teaching the Natural Sciences in the senior phase

	Frequency	Percentage
1-5 years	34	62.9
6-10 years	10	18.5
11-15 years	4	7.4
16-20 years	2	3.7
+20 years	1	1.8
*Missing	3	5.6
Total	54	99.9

This information can be represented graphically as follows:

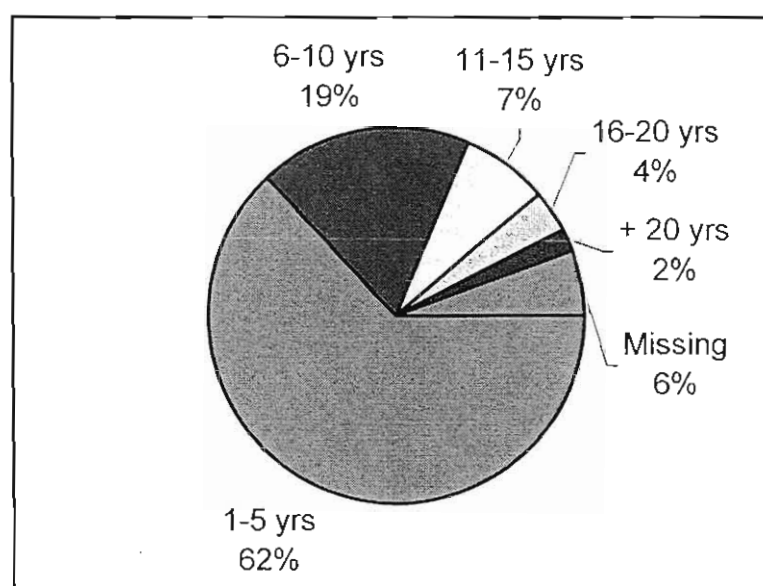


Figure 5.4: Teachers' experience in teaching the Natural Sciences in the senior phase

The vast majority (62.9%) have taught the Natural Sciences in the senior phase for five years and less. This practice affects the competency and confidence in mastering the content of the learning area.

5.2.1.2 Learners

Table 5.5: Learners' ages

	Frequency	Percentage
11	0	0
12	0	0
13	21	3
14	179	25.2
15	219	30.8
16	148	20.8
17	80	11.3
18	36	5.1
19	7	0.9
20	5	0.7
Missing	16	2.3
Total	711	100

This information can be represented graphically as follows:

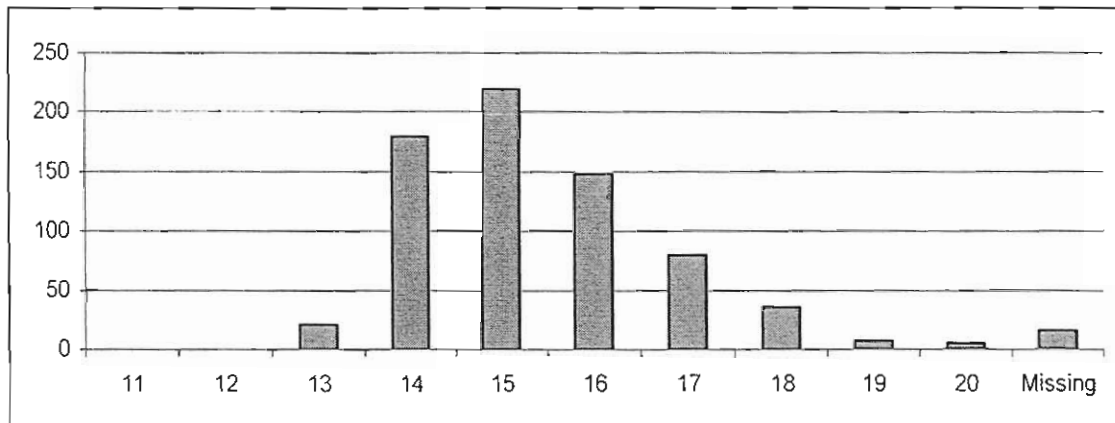


Figure 5.5: Learners' ages

A large number of learners (71%) are within the age norm for the specific grade. The fact that the majority of learners are within the same age group makes it relatively easy for the teacher to handle them, because, according to Piaget's Cognitive Theory, they are on the same level of cognitive development (*cf* 2.2.5.1).

Table 5.6: Learners' final mark (%) in the Natural Sciences in Grades 6, 7 and 8

	GRADE 6		Grade 7		Grade 8	
MARK %	Frequency	%	Frequency	%	Frequency	%
10-20	4	0.6	2	0.3	5	0.7
21-30	9	1.3	11	1.6	27	3.8
31-40	29	4.1	25	3.5	52	7.3
41-50	77	10.7	43	6	134	18.9
51-60	127	17.9	98	13.8	116	16.3
61-70	113	15.9	129	18.1	105	14.8
71-80	101	14.2	99	13.9	102	14.3
81-90	59	8.3	83	11.7	63	8.9
91-100	28	3.9	29	4.1	23	3.2
Missing	164	23.1	192	27	84	11.8
TOTAL	711	100	711	100	711	100

This information can be represented graphically as follows:

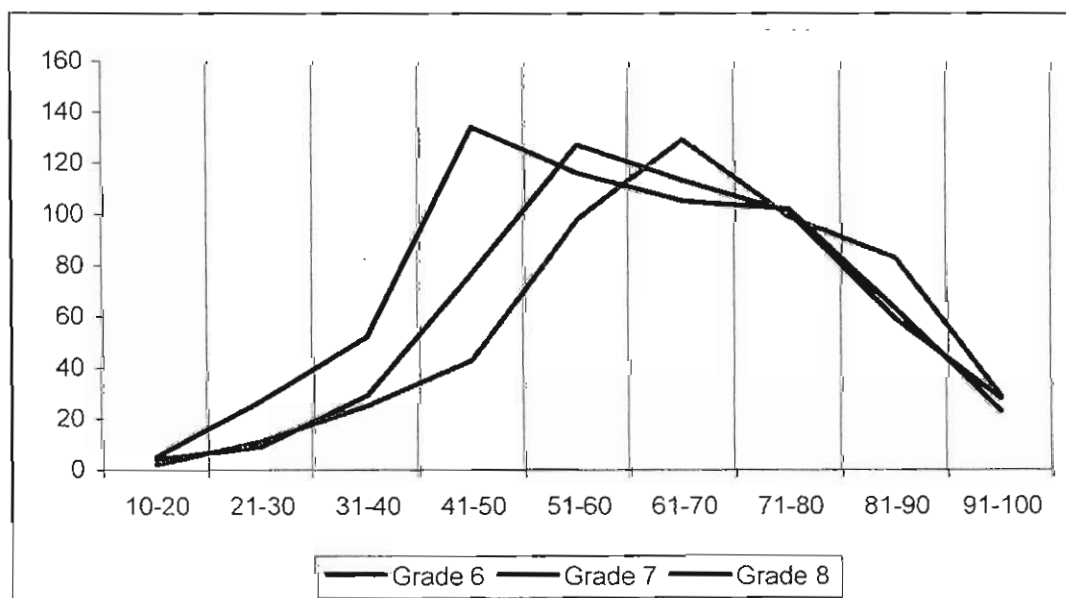


Figure 5.6: Learners' final mark (%) in the Natural Sciences in Grades 6, 7 and 8

In Grade six most learners obtained 51% to 80%. Unfortunately a large number of learners failed to respond. In Grade seven this scenario was repeated and an even larger number did not respond. In Grade eight, the majority achieved 41% to 80% and a relatively smaller number did not respond. The larger numbers that did not respond in Grades six and seven could be attributed to the fact that learners might have forgotten what percentages they obtained in the Natural Sciences, as this occurred two years ago and they were not warned in advance that this information would be required of them.

It can however be deducted that the majority of learners are of average competency in the Natural Sciences.

5.2.2 Teaching Styles

This section was expected to elicit information about the time teachers spend using a specific teaching style. This information would indicate to the researcher whether the teachers are conversant with the preferred OBE and NCS teaching styles (*cf* 2.3). Learners were also requested to give similar information regarding the teaching styles their Natural Sciences teachers use most. This was to countercheck the responses given by the teacher.

Table 5.7: Teaching styles teachers prefer: Teacher and learner responses

TRANSMISSION STYLE					FACILITATION STYLE			
	TEACHERS		LEARNERS		TEACHERS		LEARNERS	
Time %	Fre- quency	%	Fre- quency	%	Fre- quency	%	Fre- quency	%
-10	1	1.9	5	0.7	0	0	5	0.7
10	1	1.9	6	0.8	0	0	7	1
20	3	5.6	33	4.6	5	9.3	23	3.2
30	0	0	32	4.5	5	9.3	68	9.6
40	11	20.3	54	7.6	12	22.1	66	9.4
50	12	22.2	85	12	11	20.4	92	13
60	11	20.3	84	11.8	12	22.1	83	11.8
70	8	14.8	102	14.4	3	5.6	81	11.5
80	6	11.1	109	15.3	4	7.4	121	17
90	0	0	47	6.6	1	1.9	67	9
100	0	0	123	17.3	0	0	58	8.2
Missing	1	1.9	31	4.4	1	1.9	40	5.6
TOTAL	54	100	711	100	54	100	711	100

This information can be represented graphically as follows:

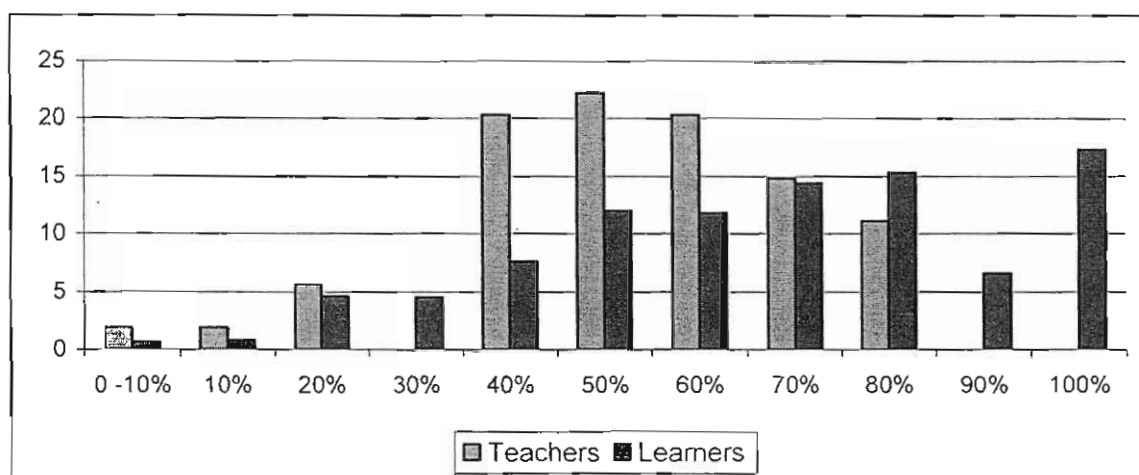


Figure 5.7a: Percentage of time spent on transmission style

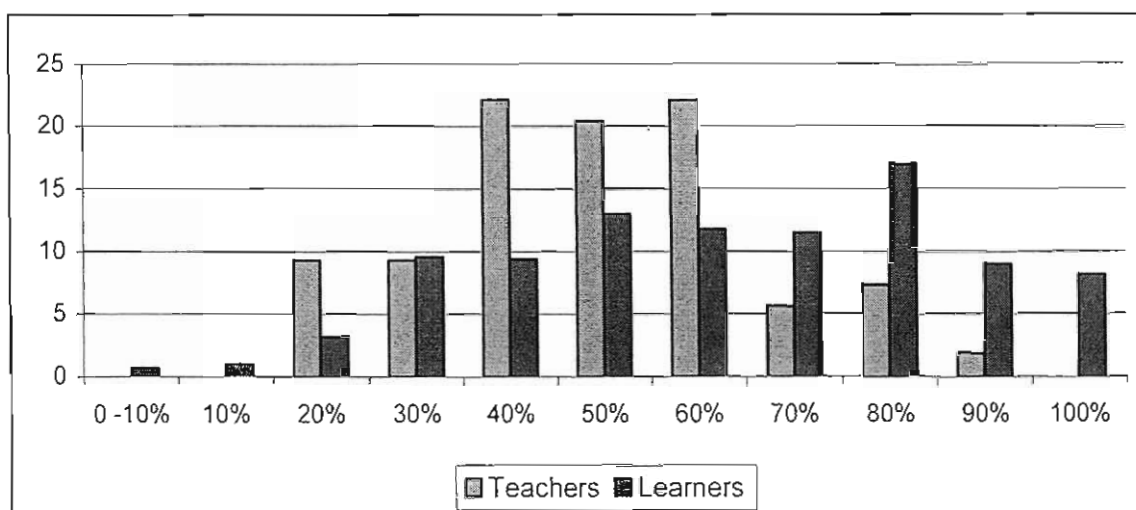


Figure 5.7b: Percentage of time spent on facilitation style

Transmission Style

88.7% of the teachers use the transmission style 40% to 80% of the time. 61.1% of the learners indicated that their teachers use the transmission style between 40% to 80% of the time. 17.3% of the learners indicated that their **teachers** use the transmission style 100% of their teaching time.

Facilitation Style

The facilitation style is used by 77.6% of the teachers for 40% to 80 % of their teaching time, with 64.8% using 40% to 60% of the time for this style. 53.3% of the learners put their teachers' use of the facilitation style at 50% to 80%.

According to the teachers the transmission-reception style and the facilitation style are utilized almost equally by them. According to the data analysis, 62.8% use the former style for 40% to 60% of their teaching time and 64.6% use the latter style for the same time span. Learners, however, differ in their estimation from their teachers. 31.4% of the learners who responded believe that their teachers use the transmission style for 40-60% of their time and 21.9% put the use of this style at 80% to 90%, whereas 17.3% claim that teachers use this at all times. 34.2% of them put the use of the facilitation style by their teachers at 40% to 60% of their teaching time.

The discrepancies between teachers' and learners' responses are alarming, but not surprising. They could be attributed to the fact that learners are most likely not in a position to make proper estimates of the time their teachers spend using one teaching style or the other. Or perhaps they are stating the reality and it is the teachers who are distorting the facts to be comply with the theory as stated in the manuals of the modern trends of teaching. The researcher would like to place the interpretation of this section on hold until the analysis of teaching methods and assessment strategies has been done. It is hoped that such information will help to clarify this as certain teaching methods and assessment strategies are consistent with certain teaching styles.

5.2.3 Teaching methods

This question necessitated teachers enlightening the researcher on the time they spend using the listed teaching methods. This information would be most useful to the researcher to determine whether teachers are utilizing a variety of methods in order to accommodate diverse learner needs.

**Table 5.8a: Time teachers spend using a specific teaching method:
Teacher responses**

TEACHING METHOD	Always		Often		Sometimes		Never	
	f	%	f	%	f	%	f	%
Lectures	9	16.7	13	24.1	17	31.5	11	20.4
Drilling	5	9.3	10	18.5	14	25.9	17	31.5
Worksheets	9	16.7	23	42.6	17	31.5	2	3.7
Presentation by learners	25	46.3	21	38.9	8	14.8	0	0
Demonstration by teachers	16	29.6	24	44.4	10	18.5	0	0
Constructing concept maps	5	9.3	7	12.9	29	53.7	9	16.7
Case studies	4	7.4	12	22.2	19	35.2	13	24.1
Making posters	5	9.3	8	14.8	22	40.7	13	24.1
Oral presentation by learners	4	7.4	17	31.5	28	51.8	4	7.4
Role-playing	7	13	7	12.9	21	38.9	15	27.8
Designing	3	5.6	10	18.5	26	48.2	12	22.2
Projects	5	9.3	9	16.7	29	53.7	7	12.9
Field trips	0	0	4	7.4	15	27.8	30	55.6
Experimenting	5	9.3	21	38.9	21	38.9	5	9.3
Questioning	33	61.1	14	25.9	4	7.4	2	3.7
Debates	2	3.7	14	25.9	25	46.3	11	20.4
Surveys	1	1.9	4	7.4	25	46.3	19	35.2
Crossword puzzles	3	5.6	7	13	20	37	23	42.6
Co-operative learning	11	20.4	22	40.8	16	29.6	2	3.7
Demonstration by learners	3	5.6	19	35.2	26	48.1	4	7.4
Brainstorming	8	14.8	10	18.5	23	42.6	8	14.8

For the purpose of easier reporting this section the "always and "often" and "sometimes" and "never" responses are added together. The following table displays the data as suggested above.

**Table 5.8b: Time teachers spend using a specific teaching method :
Teacher responses**

TEACHING METHOD	Always & Often		Sometimes & Never		Missing	
	f	%	f	%	f	%
Lectures	22	40.8	28	51.8	4	7.4
Drilling	15	27.8	31	57.4	8	14.8
Worksheets	32	59.3	19	35.1	3	5.6
Presentation by teacher	46	85.2	08	14.8	0	0
Demonstration by teachers	40	74.1	10	18.5	4	7.4
Constructing concept maps	12	22.	38	70.4	4	7.4
Case studies	16	29.6	32	59.3	6	11.1
Making posters	13	24.1	35	64.8	6	11.1
Oral presentation by learners	21	38.9	32	59.2	1	1.9
Role-playing	14	25.9	36	66.7	4	7.4
Designing	13	24.1	38	70.4	3	5.5
Projects	14	26	36	66.6	4	7.4
Field trips	4	7.4	45	83.4	5	9.2
Experimenting	26	48.1	26	48.1	2	3.7
Questioning	47	87	06	11.1	1	1.9
Debates	16	29.6	36	66.7	2	3.7
Surveys	05	9.3	44	81.5	5	9.2
Crossword puzzles	10	18.5	43	79.6	1	1.9
Co-operative learning	33	61.2	18	33.3	3	5.5
Demonstration by learners	22	40.8	30	55.5	2	3.7
Brainstorming	18	33.3	31	57.4	5	9.3

The teachers' inclination is to use the following methods more frequently than the rest:

- Questioning (87%)
- Presentation by teachers (85.2%)
- Demonstration by teachers (74.1%)

The less frequently used methods are:

- Field trips (83.4%),

- Surveys (81.5%)
- Crossword puzzles (79.6%)
- Concept maps (70.4%)
- Designing (70.4%)

So far this scenario tallies with the learners' assertion in table 5.7 above (*cf* 5.2.2). Frequent use of the first three teaching methods, which are Direct Instruction methods, suggests the use of the transmission style of teaching. This implies that learners who prefer learning through sensing and watching will be mostly accommodated through this style of teaching (*cf* 2.4.2). This clearly contradicts the National Curriculum Statement where it is indicated that a variety of teaching styles should be utilized during teaching and learning (*cf* 1.1).

Table 5.9a: Teaching methods: Learner responses

TEACHING METHOD	Always		Often		Sometimes		Never	
	f	%	f	%	f	%	f	%
Lectures	151	21.2	122	17.2	322	45.3	94	13.2
Drilling	95	13.4	66	9.3	161	22.6	300	42.2
Worksheets	243	34.2	126	17.7	248	34.9	46	6.5
Presentation by teacher	349	49.1	85	12	217	30.5	32	4.5
Demonstration by teacher	231	32.5	133	18.7	225	31.6	93	13.1
Concept maps	46	6.5	88	12.3	281	39.5	209	29.4
Case studies	181	25.5	63	8.9	226	31.8	218	30.7
Making posters	72	10.1	51	7.2	261	36.7	303	42.6
Oral presentation by learners	127	17.9	110	15.5	259	36.4	186	26.2
Role-playing	108	15.2	63	8.9	168	23.6	333	46.8
Designing	114	16	75	10.6	301	42.3	203	28.6
Projects	200	28.1	85	12	311	43.7	91	12.8
Field trips	37	5.2	54	7.6	112	15.8	462	65
Experimenting	142	20	98	13.8	321	45.1	122	17.2
Questioning	447	62.9	80	11.3	133	18.7	26	3.7
Debates	66	9.3	67	9.4	213	30	343	48.2
Surveys	73	10.3	85	12	205	28.8	279	39.2
Crossword puzzles	124	17.4	62	8.7	217	30.5	290	40.8
Co-operative Learning	175	24.6	119	16.7	255	35.9	118	16.6
Demonstration by learners	143	20.1	104	14.6	278	39	138	19.4
Brainstorming	170	23.9	85	11.9	271	38.1	158	22.2

For the purpose of easier reporting in this section, the “always” and “often” and the “sometimes” and “never” responses are clustered together. The following table displays the data as suggested above.

**Table 5.9b: Time teachers spend using a specific teaching method :
Learner responses**

TEACHING METHOD	Always & Often		Sometimes & Never		Missing	
	f	%	f	%	f	%
Lectures	273	38.4	416	58.5	22	3.1
Drilling	161	22.7	461	64.8	89	12.5
Worksheets	369	51.9	294	41.4	48	6.8
Presentation by teacher	434	61.0	249	35	28	3.9
Demonstration by teacher	364	51.2	318	44.7	29	4.1
Concept maps	134	18.8	490	68.9	87	12.2
Case studies	244	34.3	444	62.5	23	3.2
Making posters	123	17.3	564	79.3	24	3.4
Oral presentation by learners	237	33.4	445	62.6	29	4.1
Role-playing	171	24.1	501	70.5	39	5.5
Designing	189	26.6	504	70.9	18	2.5
Projects	285	40.1	402	56.5	24	3.4
Field trips	91	12.8	574	80.8	46	6.5
Experimenting	240	33.8	443	62.3	28	3.9
Questioning	527	74.1	159	22.4	25	3.5
Debates	133	18.7	556	78.2	22	3.1
Surveys	158	22.2	484	68.1	69	9.7
Crossword puzzles	186	26.2	507	71.3	18	2.5
Co-operative Learning	294	41.4	373	52.5	44	6.2
Demonstration by learners	247	34.7	416	58.5	48	6.8
Brainstorming	255	35.9	429	60.3	27	3.8

According to learners, teachers utilize methods in the following order of preference:

- Questioning (74.1%)
- Presentations (61.0%)
- Demonstration by teacher (51.2%)
- Worksheets (51.9%)

Learners indicate that the following methods are seldom used:

- Field trips (80.8%)
- Posters (79.3%)
- Debates (78.2%)
- Crossword puzzles (71.3%)
- Designing (70.9%)
- Role plays (70.5%)

There seems to be a correlation between the teachers' and learners' responses to this question. The teachers' inclination is towards the use of questioning and presentation teaching methods. It appears that learners were right after all in table 5.7 above. (Remember, the researcher suspended the interpretation of the teachers' preferred teaching style until after the analysis of the teachers' teaching methods was done, so as to validate the conflicting responses given in table 5.7). Direct Instruction methods like the ones mentioned above are directly linked with the transmission style of teaching. It becomes apparent, that the responses of the teachers did not provide a true reflection of what actually happens in the classroom.

For further analysis, the data will be clustered under the major teaching methods, namely **Direct Instruction, Indirect Instruction, Independent Instruction and Interactive Instruction**. This is to validate the analysis of the teaching methods /strategies in 5.2 above.

Data from tables 5.8b and 5.9b are used for this purpose. Percentages of both the learner and teacher responses are used and means calculated to reduce the figures for easier interpretation and comprehension. These figures represent the preferred teaching methods by teachers.

The following are the suggested clusters.

Table 5.10: Cluster A: Direct instruction

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
	38.4	Lectures	40.8	
	22.7	Drilling	27.8	
49.4	61.0	Presentation by teacher	85.2	62.9
	51.2	Demonstration by teacher	74.1	
	74.1	Questioning	87	

This information can be represented graphically as follows:

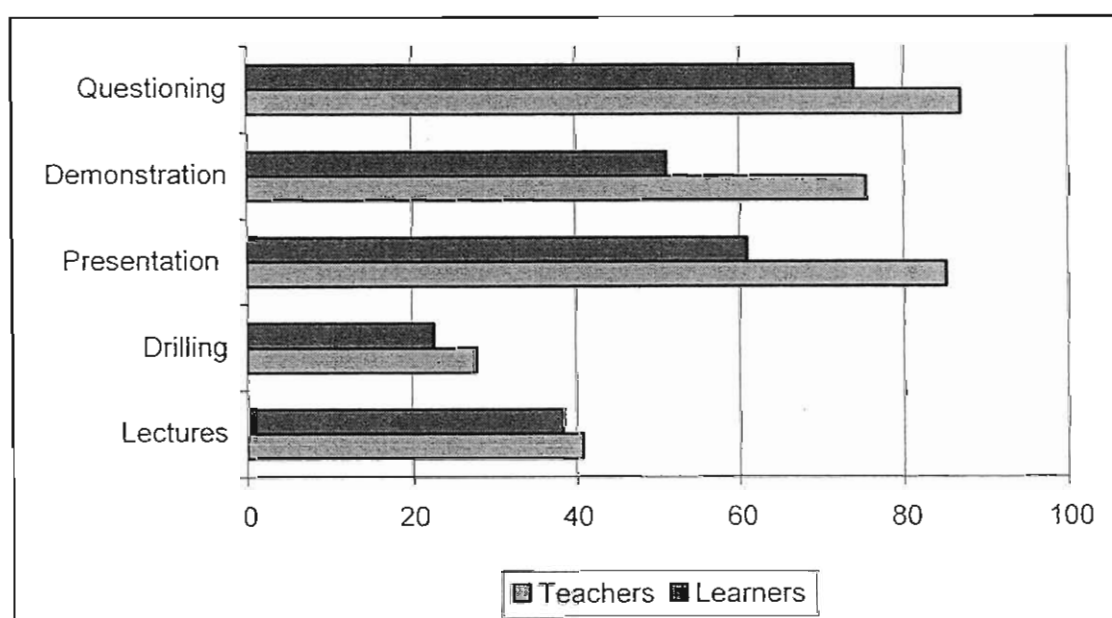


Figure 5.8: Cluster A: Direct instruction

Table 5.11: Cluster B: Independent instruction

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
	51.8	Worksheets	59.3	
	33.4	Oral presentation by learners	38.9	
33.1	18.7	Debates	29.6	39.2
	26.2	Crossword puzzles	18.5	
	34.7	Demonstration by learners	40.8	
	33.8	Experimenting	48.1	

This information can be represented graphically as follows:

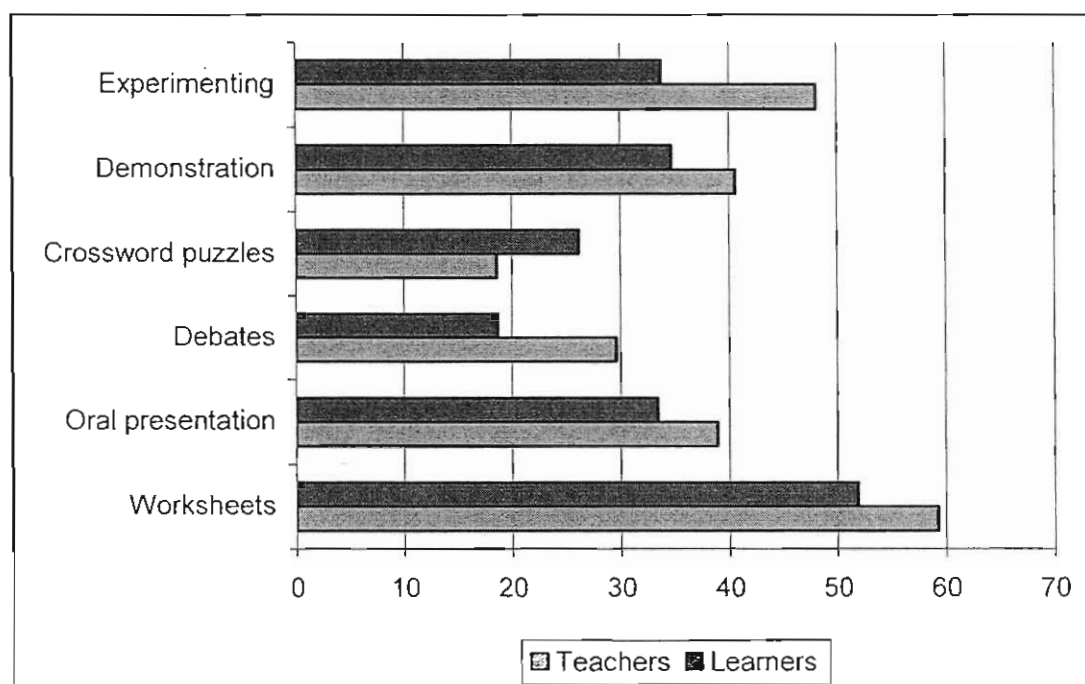


Figure 5.9: Cluster B: Independent instruction

Table 5.12: Cluster C: Interactive instruction

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
	17.3	Making posters	24.1	
	26.6	Designing	24.1	
29.0	24.1	Role-playing	25.9	33.7
	41.4	Co-operative learning	61.2	
	35.9	Brainstorming	33.3	

This information can be represented graphically as follows:

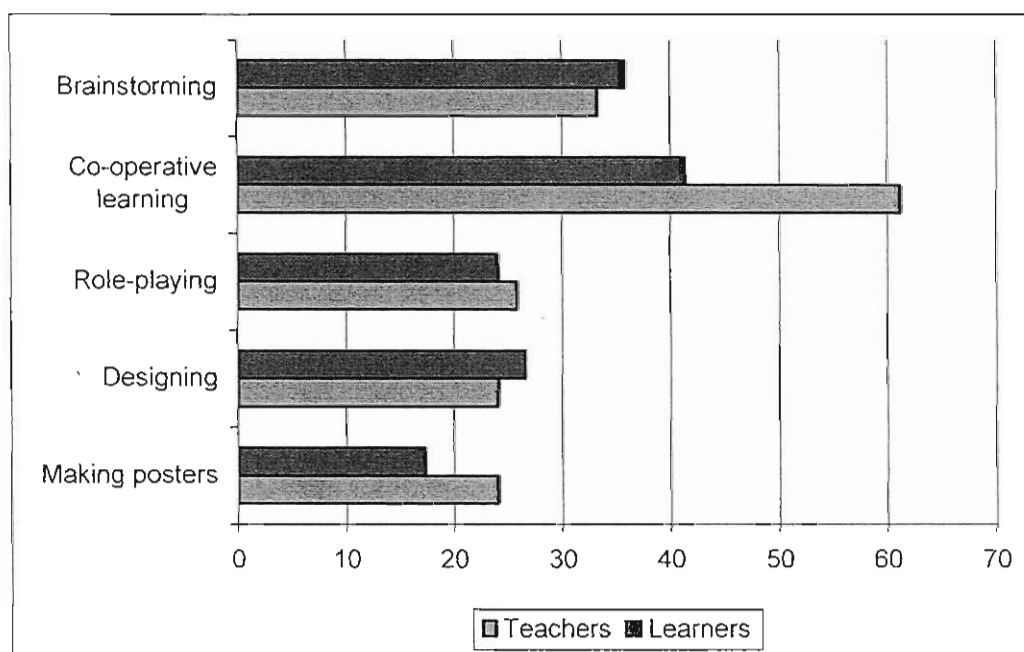


Figure 5.10: Cluster C: Interactive instruction

Table 5.13: Cluster D: Indirect instruction

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
	34.3	Case studies	29.6	
27.3	12.8	Field trips	7.4	18.0
	40.1	Projects	26	
	22.2	Survey	9.3	

This information can be represented graphically as follows:

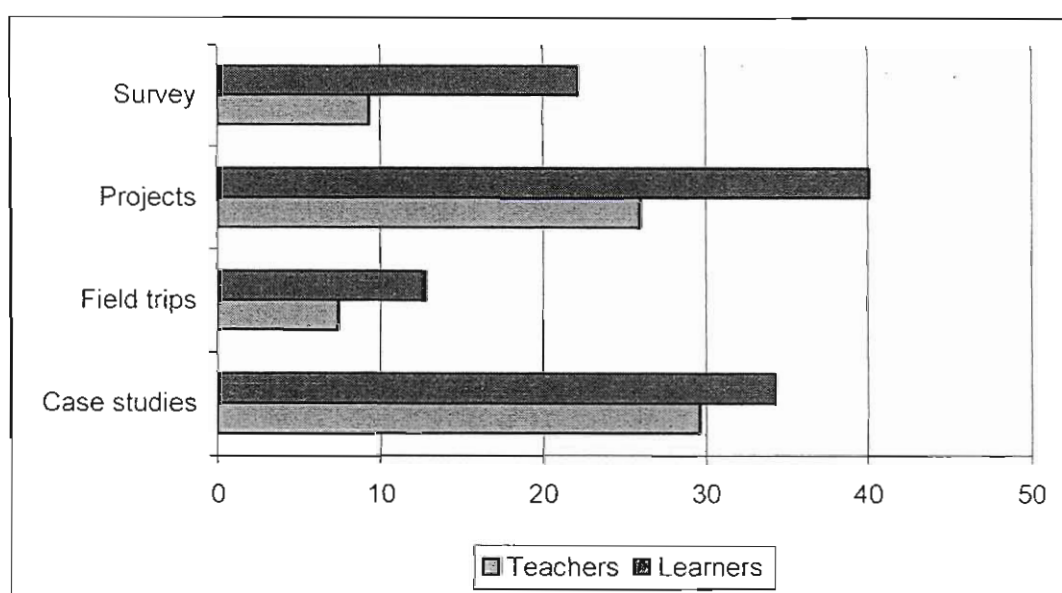


Figure 5.11: Cluster D: Indirect instruction

This data from the above clusters indicates that the most used methods are clustered under **Direct Instruction**. Teachers prefer using a variety of teaching strategies which are classified as Direct Instruction methods of teaching (a mean of 63.2 % and 48% by teachers and learners respectively). This is still more substantiating evidence of the learners' assertion in table 5.7, namely that teachers use these methods most of the time.

5.2.4 Learning Styles

This question expected teachers to indicate which of the four major learning styles (*cf* 2.4.2) are accommodated during teaching. Learners were

requested to indicate which of the four provided learning styles they prefer using.

Table 5.14: Accommodation of learning styles by teachers

LEARNING STYLE	Always		Often		Sometimes		Never	
	f	%	f	%	f	%	f	%
Sensors & feelers	13	24	23	42.6	11	20.4	5	9.3
Watchers	16	29.6	25	46.3	9	16.7	2	3.7
Thinkers	10	18.5	20	37	19	35.1	3	5.7
Doers	10	18.5	23	42.6	14	25.9	5	9.3

This information can be represented graphically as follows:

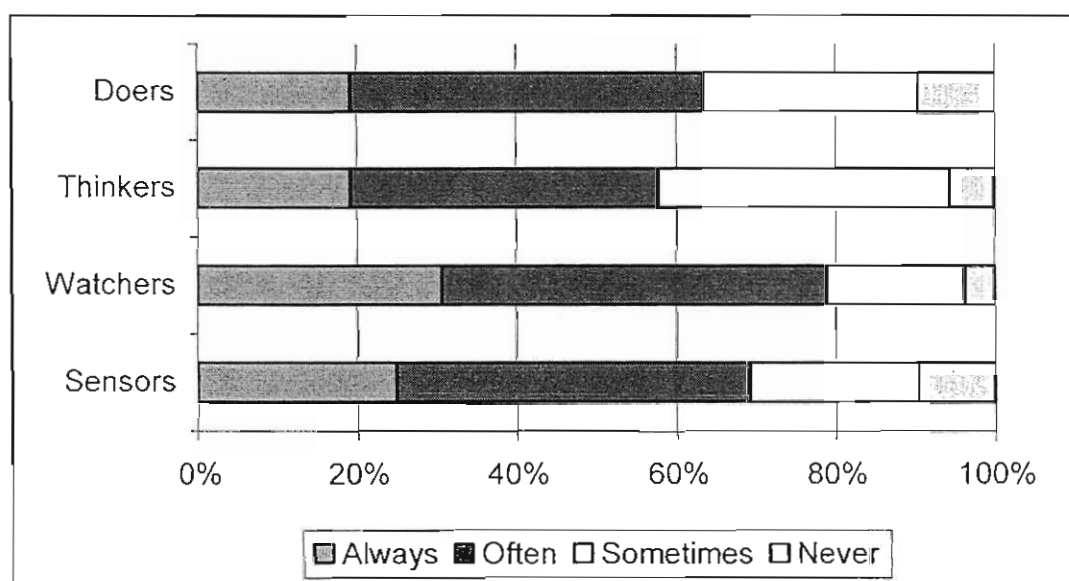


Figure 5.12: Accommodation of learning styles by teachers

Watchers (29.6%) seem to be accommodated more than the rest, followed by the sensors and feelers (24.1%) and doers (18.5%) and thinkers (18.5%). This corresponds well with the findings in 5.2.3 where it is indicated that the Direct Instruction method is the preferred teaching method. Watchers as well as sensors prefer the direct method of teaching (*cf* table 5.3).

Table 5.15: Learners' preferences of learning style

Learning Style	Frequency	Percentage
Sensors & feelers	287	40.4
Watchers	81	11.4
Thinkers	203	28.5
Doers	110	15.5
Missing	30	4.2
Total	711	100

This information can be represented graphically as follows:

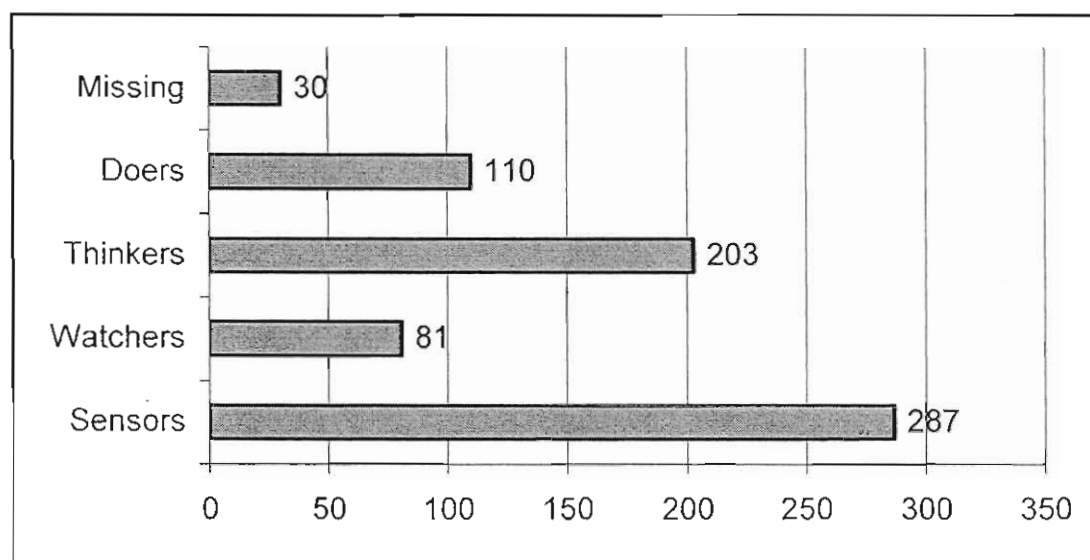


Figure 5.13: Learners' preferences of learning style

A large number of learners are sensors and feelers (40.4%) followed by thinkers (28.5%) watchers (11.4%) and lastly the doers (15.5%)

According to the findings of this study, the type of learners often accommodated by teachers in their teaching are the **watchers** (*cf* table 5.12). Thinkers are the least accommodated. Teachers' indication that they spend most of the time using Direct Instruction concurs with this finding (*cf* table 5.11). Once again, this finding supports the learners' claims in 5.7. The findings contradict the principles of Outcomes-Based Education and the

National Curriculum Statement which discourage teacher-centred approaches as the sole approach to teaching (*cf* 2.3.2). Problematic is the fact that teaching in the Natural Sciences prefer Independent Interaction and Interactive Interaction (*cf* 3.4) but this research indicates that teachers do not focus on these approaches during the teaching of the Natural Sciences. Alsop and Hicks (2001:35) report that recent studies have highlighted the importance of teachers understanding how children learn. Contrary to the larger group accommodated by teachers, learners have indicated that the most of them are sensors and feelers. This type of learner forms the second largest group that teachers accommodate (66,7%).

When one looks at the teaching methods and teaching strategies often preferred by most teachers, it appears as if teachers neither take cognizance of what education policy prescribes nor of the way their learners prefer to think and learn. Although it is advisable that teachers should not dwell mainly on the learners' preferred learning styles when teaching, it is imperative that they should be aware of them (*cf* 2.4.10). This assists them to prepare their lessons in such a way that each learner's learning style is accommodated in some way or other. It also helps teachers to know which learners to focus on in order to encourage them to use other learning styles.

5.2.5 Assessment Strategies

Maree and Fraser (2000:136) assert that assessment should be constructed to tally with the learners' preferred way of learning. They further advise that teaching activities should, at times, be constructed in such a way that learners are challenged to work outside their comfort zones, as this enhances holistic cognitive development.

Teachers were requested to indicate how often they expose learners to the provided list of assessment opportunities. Learners were also asked to indicate how often they are exposed to these assessment opportunities. The first tables of data collected from learners and teachers will be displayed in the form of frequencies and percentages. Subsequent tables will be a total of the

“always and often” and “sometimes and never” responses for easier deciphering.

Table 5.16a: Exposure to assessment strategies: Teacher responses

STRATEGY	Always		Often		Sometimes		Never		Missing	
	f	%	f	%	f	%	f	%	f	%
Analysis	8	14.8	22	40.7	19	35.2	1	1.9	4	7.4
Synthesizing	4	7.4	16	29.6	22	40.7	6	11.1	6	11.1
Planning	20	37	12	22.2	15	27.8	4	7.4	3	5.6
Providing to-the-point information	18	33.3	24	44.4	4	7.4	1	1.9	7	13
Discovery and exploration	8	14.8	13	24.1	21	38.9	6	11.1	6	11.1
Experimenting	8	14.8	16	29.6	20	37	5	9.3	5	9.3
Practical application	12	22.2	15	27.8	19	35.2	2	3.7	6	11.1
Group discussions	18	33.3	22	40.7	12	22.2	0	0	2	3.7
Action	15	27.8	12	22.2	19	35.2	4	7.4	4	7.4
Research	7	12.9	11	20.4	23	42.6	9	16.7	4	7.4
Investigation	8	14.8	18	33.3	23	42.6	3	5.6	2	3.7
Assignments	22	40.7	19	35.2	11	20.4	0	0	2	3.7
Texts and exams	20	37	17	31.5	14	25.9	1	1.9	2	3.7
Presentation and performance	8	14.8	24	44.4	14	25.9	4	7.4	4	7.4
Translation tasks	14	25.9	19	35.2	14	25.9	5	9.3	2	3.7

Table 5.16b: Exposure to assessment strategies: Teacher responses

STRATEGY	Always & Often		Sometimes & Never		Missing	
	f	%	f	%	f	%
Analysis	30	55.6	20	37	4	7.4
Synthesizing	20	37.1	28	51.8	6	11.1
Planning	32	59.2	19	35.2	3	5.6
Providing to-the- point information	42	77.7	5	9.3	7	13
Discovery and exploration	21	38.9	27	50	6	11.1
Experimenting	24	44.4	25	46.3	5	9.3
Practical application	27	50	21	38.9	6	11.1
Group discussions	40	74.1	12	22.2	2	3.7
Action	27	50	23	42.6	4	7.4
Research	18	33.3	32	59.3	4	7.4
Investigation	26	48.1	26	48.1	2	3.7
Assignments	41	75.9	11	20.4	2	3.7
Texts and exams	37	68.5	15	27.8	2	3.7
Presentation and performance	32	59.3	18	33.3	4	7.4
Translation tasks	33	61.1	19	35.2	2	3.7

Table 5.17a: Exposure to Assessment Strategies: Learner responses

STRATEGY	Always		Often		Sometimes		Never		Missing	
	f	%	f	%	f	%	f	%	f	%
Analysis	112	15.8	114	16	316	44.4	151	21.2	18	2.5
Synthesizing	84	11.8	118	16.6	260	36.6	223	31.4	25	3.6
Planning	227	31.9	105	14.8	305	42.9	56	7.9	18	2.5
Providing to-the-point information	174	24.4	116	16.3	283	39.8	101	14.2	38	5.3
Discovery and exploration	125	17.5	127	17.9	283	39.8	127	17.9	49	6.9
Experimenting	144	20.3	102	14.3	288	40.5	140	19.7	37	5.2
Practical application	116	16.3	112	15.8	286	40.2	151	21.2	46	6.5
Group discussions	246	34.6	113	15.9	288	40.5	38	5.3	26	3.7
Action	102	14.3	83	11.7	250	35.2	239	33.6	37	5.2
Research	240	33.7	117	16.4	294	41.4	43	6.1	17	2.4
Investigation	330	46.4	129	18.2	215	30.2	18	2.5	19	2.7
Assignments	464	65.2	94	13.2	121	17	10	1.4	22	3.1
Texts and exams	297	41.7	138	19.4	254	35.7	5	0.7	17	2.4
Presentation and performance	196	27.6	97	13.6	278	39.1	114	16	26	3.7
Translation tasks	209	29.3	94	13.2	292	41.1	102	14.4	14	2

Table 5.17b: Exposure to assessment Strategies: Learner responses

STRATEGY	Always & Often		Sometimes & Never		Missing	
	f	%	f	%	f	%
Analysis	226	31.8	467	65.7	18	2.5
Synthesizing	202	28.5	483	67.9	25	3.6
Planning	332	46.7	361	50.8	18	2.5
Providing to-the- point information	290	40.7	384	54	38	5.3
Discovery and exploration	252	35.4	410	57.7	49	6.9
Experimenting	246	34.6	428	60.2	37	5.2
Practical application	228	32	437	61.5	46	6.5
Group discussions	359	50.5	326	45.8	26	3.7
Action	185	26	489	68.8	37	5.2
Research	357	50.2	337	47.4	17	2.4
Investigation	459	64.5	233	32.8	19	2.7
Assignments	558	78.5	131	18.4	22	3.1
Texts and exams	435	61.2	259	36.4	17	2.4
Presentation and performance	293	41.2	392	55.1	26	3.7
Translation tasks	303	42.6	394	55.4	14	2

Teachers indicate that they use the strategies which require learners to provide precise to-the-point information more than any other (77.7%). The next preferred strategies are assignments (75.9%) and group discussions (74.1%). The least used strategy is research (33.8%).

Learners, on the other hand, posit that assignments are used more than the rest (78.5%) followed by tests and examinations (61.2%). The least used strategy is "action", according to learners (26%). It is clear that some of the suggested forms of assessment for the Natural Sciences, namely investigations, research projects, presentations and performance and translation tasks are underutilized (*cf* 3.5).

Assessment strategies were grouped in accordance with the five forms of assessment as per National Department of Education prescripts for the Natural Sciences, namely, investigations/projects, assignments, tests and examinations, presentations and performances and translation tasks (*cf* 3.5).

As in the case of the teaching method, this reduced the size of entries (assessment strategies) to five, thus making deciphering easier. Only percentages from tables 5.16b and 5.17b were used for this purpose.

Table 5.18: Cluster A: Investigations/Projects

Mean %	Learners %	Assessment strategy	Teachers %	Mean %
	31.8	Analysis	55.6	
	28.5	Synthesizing	37.1	
	46.7	Planning	59.2	
39.7	34.6	Experimenting	44.4	45.8
	26	Action	50	
	50.2	Research	33.3	
	64.5	Investigation	48.1	
	35.4	Discovery and exploration	38.9	

This information can be represented graphically as follows:

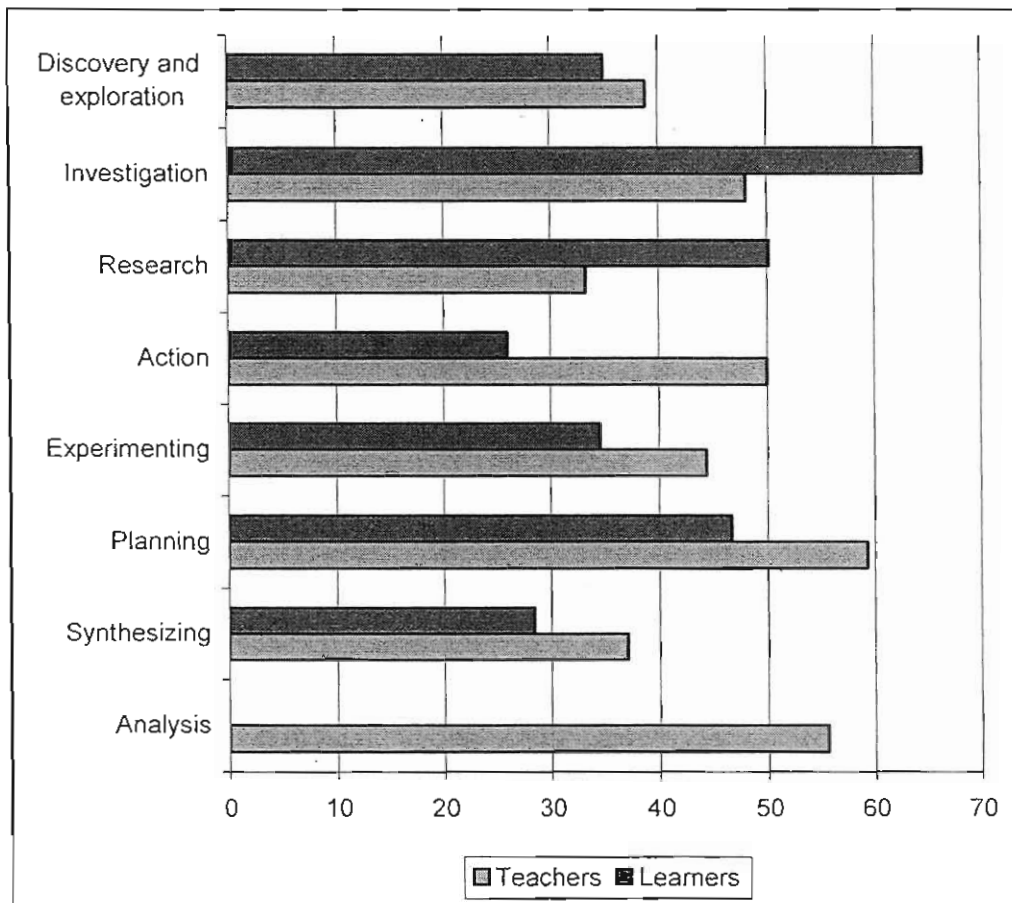


Figure 5.14: Cluster A: Investigations/Projects

Table 5.19: Cluster B: Assignments

Mean %	Learners	Assessment strategy	Teachers %	Mean %
	32	Practical application	50	
55.3	78.5	Assignments	75.9	62.9

This information can be represented graphically as follows:

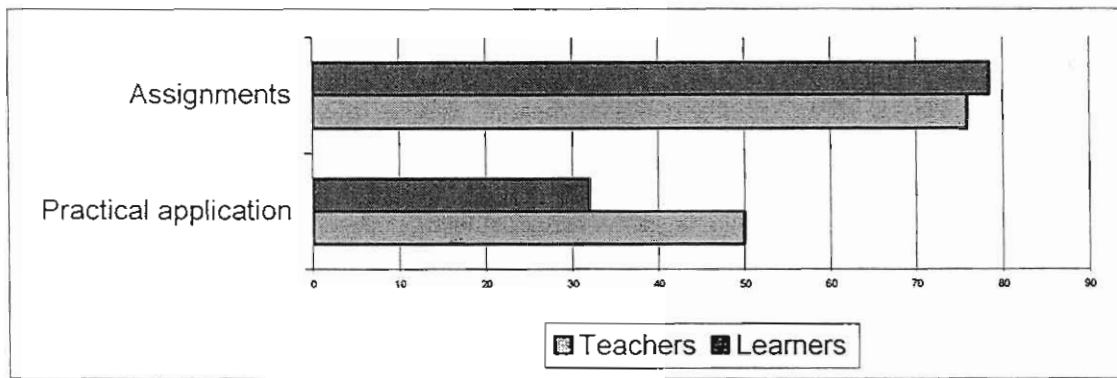


Figure 5.15: Cluster B: Assignments

Table 5.20: Cluster C: Tests and examinations

Mean %	Learners %	Assessment strategy	Teachers %	Mean %
	61.2	Tests and examinations	68.5	
50.9	40.7	Providing to the point information	77.7	73.1

This information can be represented graphically as follows:

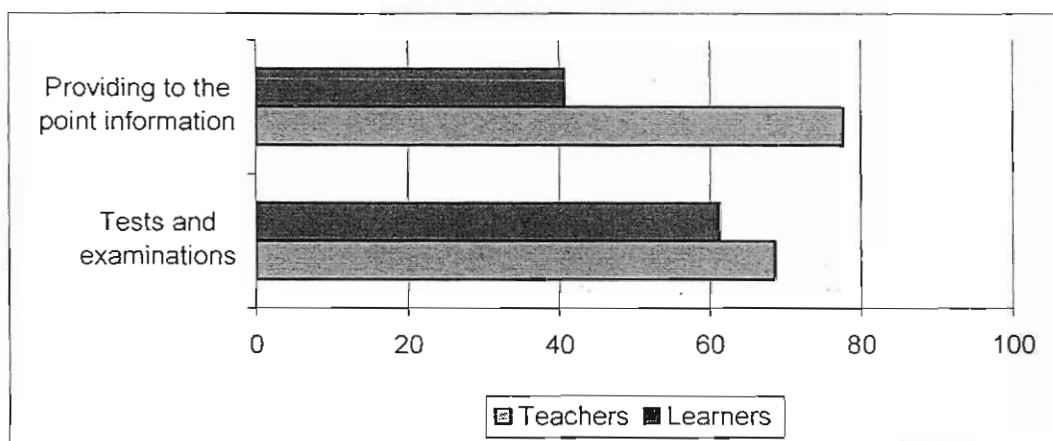


Figure 5.16: Cluster C: Tests and examinations

Table 5.21: Cluster D: Presentations and Performances

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
	41.2	Presentation and Performances	59.3	
45.8	50.5	Group Discussions	74.1	66.7

This information can be represented graphically as follows:

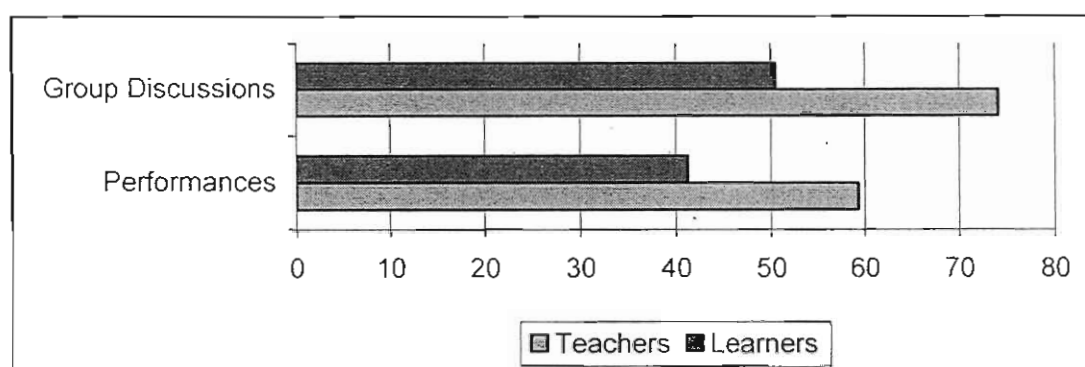


Figure 5.17: Cluster D: Presentations and Performances

Table 5.22: Cluster E: Translation Tasks

Mean %	Learners %	Teaching Methods	Teachers %	Mean %
42.6	42.6	Translation tasks	61.1	61.1

This information can be represented graphically as follows:

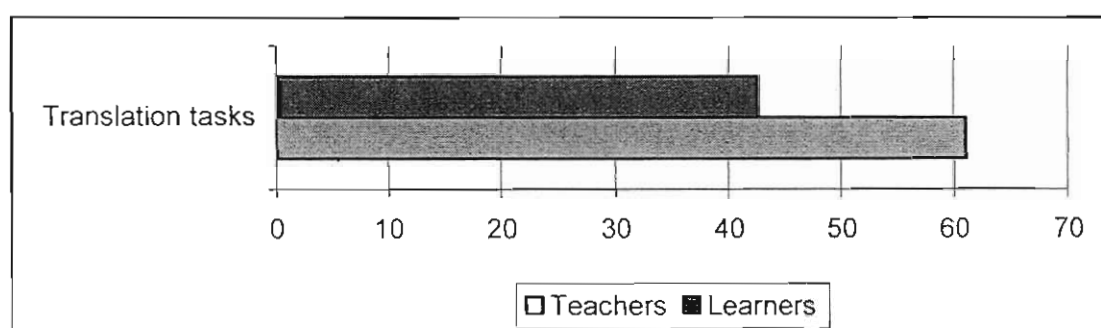


Figure 5.18: Cluster E: Translation Tasks

It appears that teachers utilize all five forms of assessment as prescribed by the NCS, but that some of them are underutilized.

The clustering of assessment strategies according to the major specified forms of assessment for the Natural Sciences consolidates previous findings that teachers prefer using Direct Instruction methods of teaching. The use of assessment strategies in cluster C above, requiring learners to provide precise to-the-point information is often associated with Direct Instruction (*cf* 2.3.2.1, 2.5.1.1).

The grouping of teaching methods according to the four major categories and that of assessment strategies according to the prescribed forms makes a comparison between the teaching methods and assessment strategies more meaningful. The following is a further analysis of the data supplied by both teachers and learners.

Table 5.23: Comparison between teachers' and learners' responses

Teaching Methods			Assessment Strategies		
	Teachers %	Learners %		Teachers %	Learners %
Cluster A (Direct Instruction)	62.9	49.4	Cluster A (Investigation /Projects)	45.8	39.7
Cluster B (Independent Instruction)	39.1	33.1	Cluster B (Assignments)	62.9	55.2
Cluster C (Interactive Instruction)	33.7	29.0	Cluster C (Tests and exams)	73.1	50.9
Cluster D (Indirect Instruction)	18.0	27.3	Cluster D (Presentations)	66.7	45.5
			Cluster E (Translation tasks)	61.1	42.6

This information can be represented graphically as follows:

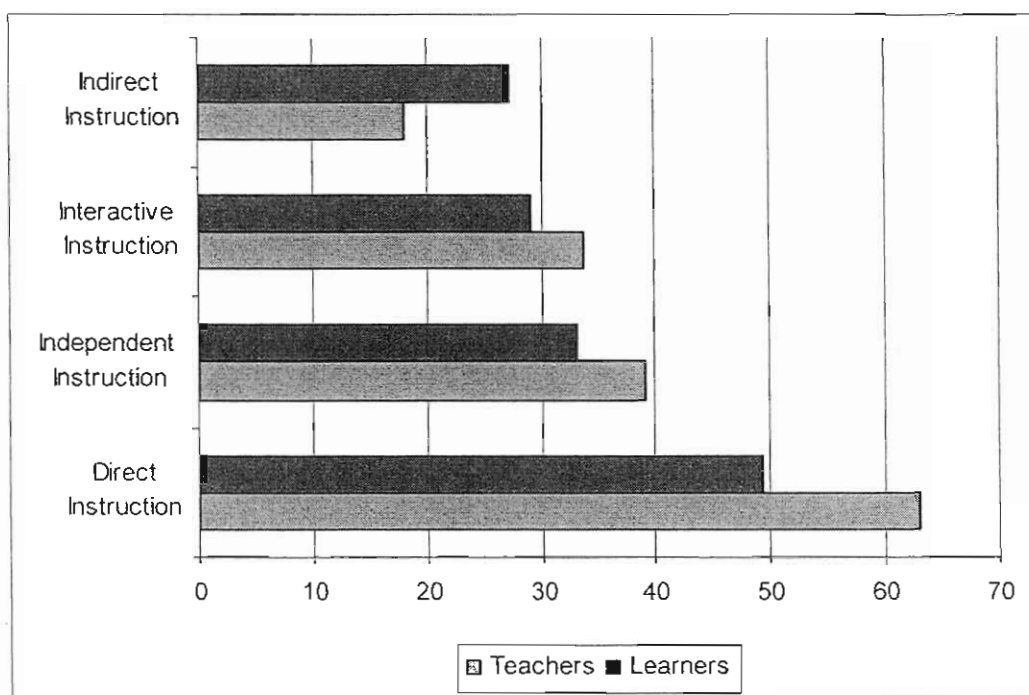


Figure 5.19a: Teaching methods: Comparison between teachers' and learners' responses

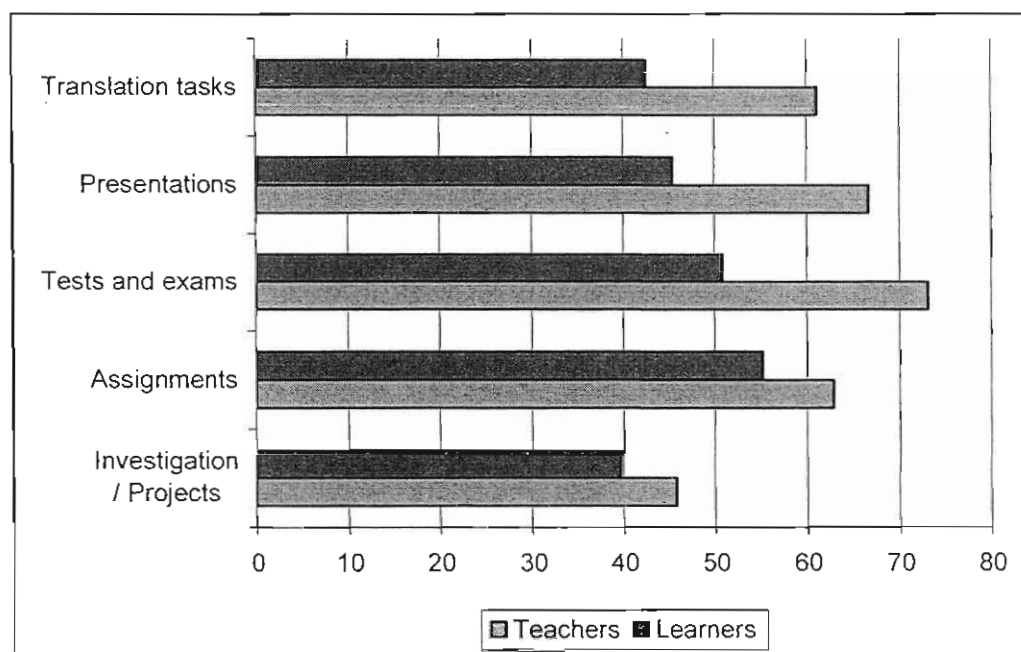


Figure 5.19b: Assessment Strategies: Comparison between teachers' and learners' responses

A comparison between teachers' and learners' responses reveals that there is a direct correlation between the responses of the learners and the teachers regarding the preference of teaching method and assessment strategy. The greatest amount of time is spent using the Direct Instruction method and tests and examinations as assessment strategies. However, teaching methods that are recommended as the most appropriate for the Natural Sciences teaching are the Interactive and the Indirect methods (*cf* 2.3.2.2, 2.3.2.3, 2.3.2.4). Direct Instruction and Independent Instruction are to be used to a limited extent. Carin & SUND (1989:93) emphasize and highly recommend the use of guided discovery, which is a combination of the indirect, interactive and direct methods. According to the findings of this study, these methods which should be used more than the rest are the least used (*cf* table 5.23).

The types of learners that are mostly accommodated by using Independent and Direct Instruction methods are the watchers and thinkers. When Interactive and Indirect methods are used, thinkers can also be accommodated as well since they will have the opportunity to debate everything presented to them. This study indicates that teachers tend to accommodate some types of learners at the expense of others (*cf* figure 5.12). This could be explained by inferring from teachers' highest academic qualifications that teachers do not have the command of the subject content matter and hence lack the skills to be versatile in their teaching styles and teaching methods (*cf* 5.2.1.1).

Assessment strategies least used by teachers, according to the findings of this study, should in essence be the most utilized, and this is in direct conflict with the dictates of the National Curriculum Statement (*cf* 3.5).

According to the policy for assessment in the Natural Sciences the weighting for the five prescribed forms of assessment should be allocated as follows: (DoE 2003:63)

- Investigations/projects 40%
- Assignments 15%

- Tests /examinations 15%
- Presentations/performances 15%
- Translation tasks 15%

From the above, it is clear that the largest weight should be allocated to investigations, whereas, according to the data, the focus is on assignments and tests where to-the-point information is requested (*cf* 5.2.5). Teachers are therefore doing an injustice to policy as well as to learners by not complying with this specification. The Natural Sciences, by their nature, are learnt through inquiry and investigation. It is therefore not surprising that there is a concern about poor learner performance in this learning area (*cf* 1.1).

5.2.5 Problems encountered by teachers during Natural Sciences teaching.

A list of possible problems teachers might encounter during the teaching of the Natural Sciences teaching was given. Teachers were requested to respond with “yes” or “no”.

Table 5.24: Problems encountered during the teaching of the Natural Sciences

	YES		NO		MISSING	
	f	%	f	%	f	%
Lack of knowledge of teaching style	13	24.	40	74.1	1	1.9
Lack of knowledge of teaching method	10	18.5	42	77.8	2	3.7
Lack of knowledge of learning styles	27	50	26	48.1	1	1.9
Lack of knowledge of assessment approaches	27	50	27	50	0	0
Lack of knowledge of assessment strategies	27	50	25	46.3	2	3.7
Lack of knowledge of learning activities	23	42.5	30	55.6	1	1.9
Lack of skills & knowledge of planning etc.	29	53.7	24	44.4	1	1.9
Lack of support & assistance in planning programmes	32	59.2	21	38.9	1	1.9
Lack of skills to link teaching method & learning styles to outcomes	29	53.7	25	46.3	0	0
Lack of skills to link learning styles & outcomes	34	62.9	19	35.2	1	1.9
Lack of skills to use assessment strategies to determine learning outcomes	31	57.4	20	37.1	3	5.6
Lack of skills to utilize learning activities to attain learning outcomes	26	48.1	27	50	1	1.9
Lack of in-service training	30	55.5	23	42.6	1	1.9

The study reflects that half of the teachers in the sample (50%) lack knowledge of learning styles, assessment approaches and assessment strategies. More than half lack knowledge of planning and designing learning programmes, 62.9% lack skills to link learning styles and learning outcomes, 53.7% lack skills to link teaching methods and learning styles to outcomes

and 53.7% lack skills to use assessment strategies to determine learning outcomes. Teachers have also indicated that there is insufficient support to assist them in dealing with the problems indicated. A lack of in-service training to assist teachers in dealing with the problems indicated, is also evident.

The above scenario is a cause for concern as it spells disaster to the effectiveness of the Natural Sciences curriculum delivery. It also gives plausible reasons why teachers do not teach and assess according to learners' learning styles most of the time. The indication earlier of underqualified teachers and limited experience in teaching the Natural Sciences could be linked to the existing scenario (*cf* 5.2.1.1).

5.2.6 Problems encountered by learners during the teaching of the Natural Sciences

Learners were given a selection of the most probable problems that might be encountered during any teaching and learning situation. They were required to indicate with a "yes" or "no", which of these problems they experience during the teaching of the Natural Sciences.

Table 5.25: Problems encountered by learners during the teaching of the Natural Sciences

PROBLEM	YES		NO		MISSING	
	f	%	f	%	f	%
Too many concrete experiences	419	58.9	255	35.9	37	5.2
Too many lecturers, explanations and documentation	355	49.9	308	43.3	48	6.8
Too much reading and finding out things for oneself	393	55.2	277	39	41	5.8
Too much practical work(doing projects)	368	51.8	315	44.3	28	3.9
Too many abstract experiences	363	51.1	311	43.7	37	5.2
Not enough lectures, explanations and demonstrations	255	35.9	424	59.6	32	4.5
Not enough time to do things on one's own	374	52.6	313	44	24	3.4
Too much co-operative group work	323	45.4	356	50.1	32	4.5

In order of importance learners experience the following as problematic:

- Too many concrete experiences (58.9%)
- Too much reading and find out things for oneself (55.2%)
- Not enough time to do things on one's own (52.6%)
- Too much practical work (51.8%)

These findings almost tally with the notion these learners expressed in their responses about the teaching methods their teachers prefer. Experiencing too many concrete activities and too much reading implies the use of Direct Instruction methods.

5.3 CONCLUSION

The expose in the preceding paragraphs is a clear indication that there is cause for concern. It is evident that teachers need a lot of support from relevant stakeholders in order to cope with the demands made by the National Curriculum Statement for teaching and learning. Innovations in education dictate that teachers should be well vested in modern approaches of teaching and learning (*cf* 2.3, 2.4).

It is for this reason that the researcher intends to contribute towards the effective teaching and learning of the Natural Sciences by designing a programme in the form of guidelines that might help teachers overcome some of the concerns raised through the questionnaires. This programme is only a drop in the ocean towards achieving optimum results in teaching and learning the Natural Sciences, as teachers need a lot of in-service training, according to their responses. Hopefully it will make a difference.

The following chapter focuses on a teaching and learning programme that intends to link teaching methods and assessment strategies to learning styles during the teaching and learning of the Natural Sciences in Grade nine.

CHAPTER SIX

A TEACHING AND LEARNING PROGRAMME TO ADDRESS LEARNING STYLE DIVERSITY IN THE NATURAL SCIENCES

6.1 INTRODUCTION

The previous chapter identified several problems in the teaching of the Natural Sciences in Grade nine (senior phase). It appears as if teachers are not yet knowledgeable and skilled to address learning style diversity in the teaching of the Natural Sciences. This prompted and spurred the researcher to design a guiding document for the teachers of the Natural Sciences.

This chapter intends to offer simple basic practical advice to teachers of the Natural Sciences. Although the study was conducted using Grade nine learners as a sample, the document could be applied to any level as the principles used are generic to the teaching of the Natural Sciences.

Before embarking on the actual envisaged model, there are certain pertinent facts that have to be highlighted as the most crucial and central to effective learning and teaching of the Natural Sciences. They must be taken into account whenever teachers do their lesson preparation.

The following are the facts which are considered noteworthy;:

6.1.1 Knowledge of the learners is essential

This is central to the study. Knowing the types of learners will enable the teacher to:

- accommodate the relevant learning styles and prepare activities accordingly, as well as plan the best group formation (to be explained later);
- fathom the didactic level at which they are and what prior knowledge they have in relation to the topic at hand. According to Woolhauch (1991:89),

learners' prior knowledge affects learning as it is believed that it is the most important single factor that influences learning; and

- gauge the learners' level of competency in other learning area concepts that are relevant and applicable to the topic e.g. language of learning and mathematics competency.

6.1.2 Thorough understanding of content

This is an important aspect as it instills confidence in the teacher.

6.1.3 Accessibility of resources to all should be ascertained

Most schools do not have well equipped laboratories. This should not be used as an excuse for not providing adequate resources to learners. Outcomes-Based orientated teachers of the Natural Sciences are expected to be inventive and innovative. They should improvise and also resort to using whatever resources abound in their learners' learning environment

6.1.4 Sensitivity to gender

All the activities should be relevant to both females and males.

6.1.5 The composition of groups should vary accordingly to the need

The following questions should assist the teacher in effective group formation. These questions are formulated by Bently and Walts, as quoted in Parkinson (1994:94-95):

- What purpose does the teacher have in mind?
- Are a variety of skills or similar skills needed in each group?
- Do learners need to be at the same cognitive level or at different levels of cognitive development?
- What problems does the teacher foresee?

6.1.6 Equipping learners with process skills essential for creating Outcomes-Based tasks should be kept in mind

These form the basis of achieving the three learning outcomes of the Natural Sciences. They are the tools that the learner must use in order to create meaning and structure from new information and experience (DoE, 2002:13).

There are eleven process skills:

- Observing and comparing data
- Measuring data
- Recording information
- Sorting and classifying information
- Interpreting information
- Predicting the outcome from data at hand
- Hypothesizing
- Questioning the situation
- Planning a science investigation
- Conducting a scientific investigation
- Communicating scientific information, using different forms such as maps, models, tables, graphs.

6.1.7 Learning outcomes and assessment standards should always be borne in mind when planning a lesson

Learning outcomes ensure integration and progression in the development of concepts and skills through the assessment standards (DoE, 2002:9).

6.1.7.1 Learning outcome1: scientific investigations

The learner will be able to act confidently on curiosity about natural phenomena and to investigate relationships and solve problems in scientific technological and environmental context.

Assessment standards (AS) are:-

- Planning investigations
- Conducting investigations and collecting data
- Evaluating data and communicating findings

6.1.7.2 Learning outcome 2: constructing science knowledge

The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

Assessment standards are:

- Recalling meaningful information when needed
- Categorizing information to reduce complexity and look for patterns
- Interpreting information
- Applying knowledge to solve problems that are not taught explicitly

6.1.7.3 Learning outcome 3: science, society and the environment

The learner will be able to demonstrate an understanding of the interrelationship between science and technology, society and the environment.

Assessment standards are:

- Understanding science as a human endeavour in cultural contexts
- Understanding sustainable use of the earth's resources

6.1.8 Necessary assessment forms should be kept in mind at all times when planning activities

The assessment forms and their weighting for the senior phase are (DoE, 2003:63):

- Investigation and projects (40%)
- Assignment (core) (15%)
- Presentation and performance (15%)
- Translation tasks (15%)
- Tests and examinations (15%)

A short description of what comprises the above follows.

6.1.8.1 Investigations and projects

These comprise site visits, excursions, building models, interviews, compiling tables and research. Investigations are used to find evidence in order to solve problems.

Assessment tasks (group or individual) could be phrased as follows;

- describe an experiment to.....
- write a report on.....
- design a model to illustrate.....
- make a sketch of.....

6.1.8.2 Assignments

These comprise calculations, applications of formulae and balancing equations. Assignments are used to solve problems using acquired facts after instruction, with clear guidelines. *(Note the difference between assignments and investigations)*

Assessment tasks could be phrased as:

- make a mind map of.....
- complete the worksheet on the.....
- calculate the.....
- make a flow diagram of.....

6.1.8.3 Tests and examinations

These are used to get learners to recall information and to use cognitive skills in a specified time (DoE, 2003:48).

6.1.8.4 Presentations and performances

These comprise oral presentations, demonstration by learners, making posters, debates, discussions and role playing (DoE, 2003:52).

Assessment tasks could include:

- conduct an experiment to show that.....
- make a poster to illustrate the.....
- debate the effects of.....
- discuss the formation of.....
- make a flow diagram of.....

6.1.8.5 Translation tasks

These comprise changing words into diagrams, tables into graphs, pictures into words, graphs into words and *vice versa* (DoE, 2003:57).

Assessment tasks could be phrased as:

- Look at this picture and write /tell what it says.

- Read this paragraph and make a picture out the story.
- Display the above information as a bar chart.
- Write the information on this graph in words.

6.1.9 The four major teaching methods with various teaching strategies should be remembered and implemented at all times

These have to be consciously selected for a specific lesson in order to attain a specific outcome while addressing diversity in learning styles of the learners.

The four major teaching methods with some of the teaching strategies (the list is not exhaustive but suggestive) are:

Table 6.1: Major teaching methods and teaching strategies

Direct Instruction methods and strategies	Indirect Instruction methods and strategies	Independent Instruction methods and strategies	Interactive Instruction methods and strategies
Lectures	Case studies	Worksheets	Making posters
Drilling	Field trips	Oral presentation (learners)	Designing
Presentation by teachers	Projects surveys	Questioning	Role playing
Demonstration by learner	Nature trails	Crossword puzzles	Round robin
Chalkboard work	Computer modelling	Demonstration (learner)	Debates
Note taking	Devising games	Brainstorming	Question groups
		Experimenting	Research groups
		Films/ videos	Interviews
		Newspaper clippings	Jigsaw
		Expositions	Quizzes
		Library visit	Miming
		Concept maps	

It is of utmost importance to ascertain learners' learning styles so that the teaching method accommodates a large variety of learners.

6.1.10 The four learning styles that are the cornerstones of planning

The major learning styles are sensing and feeling, watching, thinking and doing (*cf* 2.4.2). These learning styles will be linked to the eleven process skills which were mentioned earlier in the chapter (*cf* 3.3.3.1).

Table 6.2: Major learning styles with preferred learning processes

Sensors and feelers	Thinkers	Doers	Watchers
- sorting and classifying -conducting a scientific investigation -communicating science information using different forms (mainly tactile descriptors such as colour, texture, sound, smell, etc.)	-sorting and classifying information -interpreting information -predicting the outcome from data -hypothesizing -questioning the situation -planning a scientific investigation -conducting a scientific investigation -communicating scientific information using different forms (e.g. writing, telling, drawing, graphs, etc.)	-measuring data -conducting a scientific investigation (using mainly drawings and models)	-observing and comparing data -recording information -questioning the situation -communicating scientific information using different forms (mainly drawings and descriptions of processes)

This cursory overview of the concepts pertinent to the Natural Sciences was done because they form the basis of the ensuing suggested guide for teachers of the Natural Sciences. What follows is an attempt to design learning activities in which teachers can link teaching methods/ strategies and assessment strategies to learning styles.

The guide is based on Grade nine work but the principle applied can be extended to any grade. Topics which are used for the programme will be selected from only two knowledge areas, namely **matter and material** and **energy and change** (cf 3.3.3.1). The researcher felt that as this is only a guiding document for teachers, it will not be necessary to use all the four knowledge strands. These could be used in further research or publications by the same or another researcher

This guide should not be viewed as a replacement of the teachers' learning programme or lesson preparation. The primary aim for its development is to indicate how a variety of teaching methods and assessment strategies can be utilized to accommodate a range of learning styles in one classroom setting in order to achieve the desired learning outcomes.

It is hoped that the production of this guiding programme will assist teachers and add some value towards effective and efficient teaching of the Natural Sciences.

6.2 A TEACHING AND LEARNING PROGRAMME FOR THE NATURAL SCIENCES

Based on the literature review and the empirical research this programme was developed. As variety and diversity were the keywords for designing this programme, the theoretical framework underpinning the programme can be explained as follows.

Learning theories such as Memory Psychology, Behaviourism, Cognitive Psychology and Constructivism underpin the design of the programme. It is necessary that all these learning theories are evident, as each one implies a certain way of teaching and assessing learners (*cf* 2.6). This programme is therefore based on Direct Instruction, Indirect Instruction, Independent Instruction and Interactive Instruction. In this way all four major learning styles, namely sensors and feelers, watchers, thinkers and doers are accommodated through a variety of teaching methods and assessment strategies.

The following two knowledge strands form the basis of the programme that follows: **matter and materials** and **energy and change**.

MATTER AND MATERIALS: Theme: The particle nature of matter

Topic	Teaching methods and strategies	Learning styles	Activities						Suggested assessment tasks	Learning outcomes and assessment standards	
Atoms and molecules	- Teacher presentation - Chalkboard - Lecturing - Designing - Worksheets	Watchers Thinkers Doers Sensors and feelers	(To be done in groups). Give each group at least five different atomic models or drawings. Ask each group to identify the parts, using worksheets similar to this one (thinkers, doers, watchers, sensors and feelers).						Assignment Give learners a table of elements with the atomic number and the atomic masses and ask them to: 1. Calculate the number of protons, electrons and neutrons (thinkers, doers) 2. Identify isotopes (thinkers, doers, watchers) 3. Construct models of the other isotopes (thinkers, doers, watchers, sensors, feelers) 4. Find out about technological use of the concept (thinkers)	L.O. 2 Constructing science knowledge AS4; AS5; AS6	
			Models/ drawings	Particles at centre		total	Particles outside charge	+			Total no. of particles
				Colour charge	+						
			Carbon								
			Iron								
			Oxygen								
			Copper								
			- Use these results to explain the concepts "atom" in terms of protons and neutrons (nucleus) electrons. The sum totals of a + b particles, the atomic mass and the number of 'a' particles as the atomic number. Explain particles and their charges (thinkers, watchers) - Use the table above to explain the concept "isotope" cat iron as an example (thinkers, watchers) - Explain "molecules" as a product of two or more atoms that combine in a fixed proportion (thinkers, watchers)								

Topic	Teaching methods and strategies	Learning styles accommodated	Activities	Assessment tasks	Assessment standards (AS) and Learning outcomes (LO)
	Discussion Brainstorming Reading	Thinkers Watchers	Re- cap Grade 8 work i.e. definition of elements and compounds, Word Chemical equation, properties of non-metal and metals, properties of oxygen, carbon dioxide and hydrogen. Homework to revise the all of the above (thinkers, watchers)	- Classwork - Write elements in words and ask learners to write/ say the symbols whether a metal or non-metal (doers, watchers, thinkers)	LO 2 AS 4
Symbols of common elements and compounds	Direct Instruction Independent Instruction - Presentation by teacher - Chalkboard - Worksheets - Oral presentation by learners	Watchers Doers Thinkers Sensors and feelers	- Display a large chart of the periodic Table of Elements (whose elements are written in full and in symbols). Let each learner <u>write</u> those that they <u>identify</u> in their workbooks (including the symbol). Explain to learners that the chart they see has all <u>known</u> elements, but they are only going to focus on the first 20 + iron + copper and lead (sensors, feelers, doers) - Have a display of all available metals and non-metals at hand, especially those that are elements. Let learners classify them according to metals and non-metals. Let them locate the position of the substance/elements on the chart i.e. on the left side of the Periodic Table. Explain the concept of group and periods. Emphasize that symbols are written in <u>capital letters</u>. use any elements on the periodic table to explain what each letter and number represents e.g. number at top = atomic number.	Assignment (group work) Let each group choose any two elements of the 23 randomly and design a poster with the following information (suggestion) learners could role play this task: Name..... Atomic number... Mass number..... Protons, neutrons and electrons state of matter i.e. solid or gas; metal or non-metal. Uses of the elements (thinkers, watchers, doers, sensors, feelers) Let each group present or role play their assignment in class.	LO 2 AS 4 AS 5 AS 6 AS 7 LO 3 AS 8

Topic	Teaching methods and strategies	Learning styles accommodated	Activities										Assessment task	Learning outcomes & Assessment
Compound and chemical bonding	- Lecturing - Pesentation by teachers. - Brain- storming - Questioning - Worksheets - Investigation	Watcher Thinkers Doers Sensors and feelers	(To be done in groups). Display a chart of atoms of the first 20 elements of the periodic table. Provide each group with a table like this: (thinkers, doers, sensors, feelers, watchers)										Translation task Investigation assignment Let learners make/ draw models of ionic and covalent bonds with an oral or written explanation. Learners could also role -play or mime this activity (doers, thinkers, sensors, feelers, watchers)	LO 1 AS 3 LO 2 AS 4 AS 5 AS 6 LO 3 AS 7
			Elements	group	Atomic number	Electron on shell				Electrons on last shell				
					1	2	3	4						
			Hydrogen											
			20 calcium											
			Discuss findings as follows : (watchers, sensors, feelers) - The number of electrons on the outer shell is the same as the group number - The number of shells for each atom is the same as the period number (keep referring to diagrams and the periodic table and their findings) - Explain that for compounds to be formed, two or more atoms have to lose or gain electrons from one another. It is important at this stage to point out that all atoms aspire to have a full outer shell. You should ask learners to brainstorm which atoms they think would react with which and why (thinkers, watchers)											
Compounds and chemical bonding	Lectures Investigation	As above	- Introduce the concept of "Cations " and "Anions" (thinkers, sensors, watchers) - Let learners identify atoms that could easily be "Cations" or "Anions"										Let each group work with five of the house	LO2 AS5

	Worksheets Brainstorming Presentation by teacher		(refer back to the brainstorming session) (thinkers) - Draw their attention to the fact that the atoms they have identified as prone to becoming Cations are of elements of groups 1 and 2 and those prone to becoming anions are in group 6,4, and 7. - Explain that a type of reaction formed in this manner is called an ionic reaction and the bond between the two atoms is an ionic bond. The reaction is called a spontaneous reaction (watchers, thinkers) - Explain covalent bonding as sharing of electrons, using the reaction between hydrogen and chlorine as an example (thinkers, doers, sensors, feelers) - Ask learners to brainstorm chemicals found in the household. Write them on the chalkboard. Examples are table salt, eno's, baking powder, soap, water, sodium bicarbonate, sugar vinegar, paraffine (sensors, watchers)	chemicals and find out which elements have combined to form it (doers, thinkers, sensors, watchers). They should also indicate whether they can identify any of the elements in the compound.	
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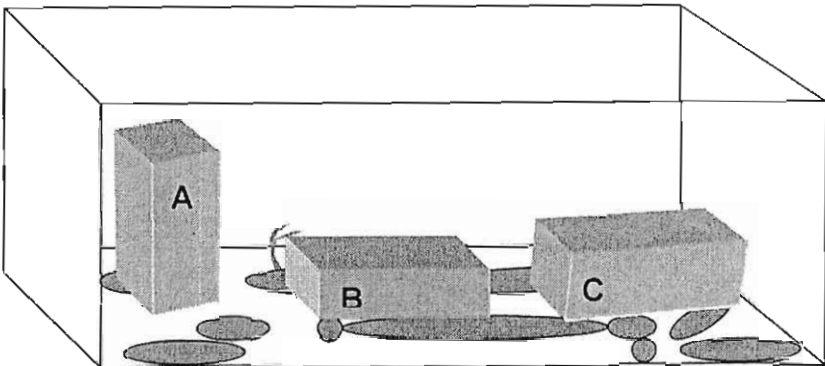
Topic	Teaching method	Learning styles	Activities				Assessment tasks	LOs & ASs
Balancing chemical equations	Lecturing - Teacher demonstration - Brainstorming - Worksheets - Role play - Investigation	Thinkers Watchers Doers Sensors and feelers	Introduce the concept valency by referring back to the structure; give learners models/diagrams of different atoms. Let them identify the number of electrons on the outmost shell. They should indicate whether the atom will need to lose or gain electrons to be stable. Use a worksheet as follows: (thinkers, sensors, feelers, doers)				- Prediction - Let learners pair those atoms they predict will react spontaneously and give reasons. This could be written, role-played or oral (thinkers, doers, sensors, feelers, watchers) - Chemical reactions of different types to balance	LO1 AS's 1,2,&3 LO2 AS's 2,5,&7 LO2 AS4
			Element(atomic model diagram	Number of electrons outer shell	Lose or gain	Number of electrons lost or gained		
			Sodium (Na)	One	Lose	One		
			Calcium (Ca)	Two	Lose	Two		
			Chlorine (Cl)	Seven	Gain	One		

			Explain that the number gained or lost is that atoms valency or bonding number and that when two atoms of the same valency react or two different valencies react a molecule is formed. Demonstrate this either using models or diagrams. This explains the concept "chemical formula" of a compound. (Make sure that learners are competent in balancing mathematical equations, otherwise the learners will not be able to understand this concept.) (watchers, thinkers, sensors, feelers) Explain the concept "polyatomic ion" and supply the names of these with their chemical formulae and valency numbers. (N.B. This section is extremely important in chemistry. Make sure that learners are very competent and confident with it.)						
Reaction of metals with oxygen and water	Note-taking Lecturing Worksheets Textbook	Watchers, sensors and feelers thinkers doers	Design a worksheet to investigate the reactivity of metals. (Use group work). N.B: Remember the first three metals of group 1 are highly reactive with oxygen. Supervise this activity and give clear precise instructions. The worksheet should be as follows: (senors, feelers, doers, thinkers, watchers).		LO1 AS's 1,2,&3 LO2 AS's 2,5,&7 LO2 AS4				
			<table><tr><td>Element</td><td>Reaction with air/oxygen</td><td>Reaction with cold water</td><td>Reaction with warm water</td></tr></table>			Element	Reaction with air/oxygen	Reaction with cold water	Reaction with warm water
			Element			Reaction with air/oxygen	Reaction with cold water	Reaction with warm water	
As there will be no spontaneous reaction with group 2 metals and copper + iron, heat them first and explain spontaneous and non-spontaneous reactions. Let learners record their observation in terms of fastness of reactions such as:									

Acids and bases	Teacher demonstration Chalkboard Lectures Investigation Questioning	Sensors Feelers Watchers Doers	colour, touch and anything they have observed (this investigation leads to the fact that metals of group 1 are more reactive than those of group 2). The soapy feeling they should have reported indicates a common property of alkalinity. (Keep labeled samples of the product of reactions for the next lesson). Refer learners to their text book for further reading on these concepts. Design a worksheet as follows (group work) : <table border="1"> <tr> <td>Solution</td> <td>Colour in red litmus paper</td> <td>Colour in blue litmus paper</td> <td>Colour in universal indicator</td> </tr> </table> For solution, use the products that were kept from the reactions of oxygen and water as well as samples of dilute acids. Learners record their observations. This leads to identification of alkalis and acids. (doers, thinkers, sensors, feelers, watchers) In groups. Let learners have two test tubes $\frac{1}{4}$ filled with alkali solution e.g. sodium hydroxide and an acid e.g. dilute hydrochloric acid. Let them add a few drops of universal indicator in the dilute hydrochloric acid only. Let them slowly add the alkali into the acid and stop pouring immediately they observe a colour change. Let them note if there has been any change in temperature in the test tube that contains the acid. Let them record all their observations. Guide them as to what they should observe. Discuss what the change in temperature means, colour change means, - learners should be able to participate positively because they would have learned that in any chemical reaction heat is either taken in or taken out. They also learned what the product reaction is, namely water and salt. (There will have been a precipitate formed). Explain that when an acid react with an alkaline the product is a salt and water.	Solution	Colour in red litmus paper	Colour in blue litmus paper	Colour in universal indicator	Learners do the following: - Write the chemical equations in symbols and balance them (thinkers, doers) - Indicate if the bonding is ionic or covalent (thinkers) - Arrange metals in their order of fastness of the reaction (doers, sensors, feeler, watchers, thinkers) - Predict what would happen if instead of oxygen they used helium and explain in terms of electron structure (thinkers) - Investigate the use of noble gases (doers, thinkers)	LO1 ASs 1,2&3 LO3 ASs 2,6,& 7 LO3 ASs 8&9 LO1 ASs 1,& 2 LO3 AS8
			Solution	Colour in red litmus paper	Colour in blue litmus paper	Colour in universal indicator			

				• Explain rusting of iron roots, disintegrating of steel wool if used and left exposed to air (thinkers) • Write balanced equations of the reactions • Give them more equations to balance • Make a poster of a flow diagram showing the industrial use of the concept of neutralization (doers, watchers) • Let learners identify bases and acids in their house holds and do the following: - Write down their chemical formulae (sensors, feelers, watchers) • Let learners identify dangerous house hold alkalis and their first aid treatment (sensors, feelers, doers)	
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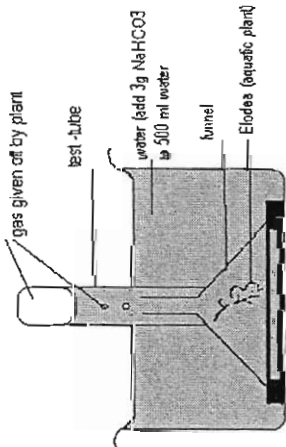
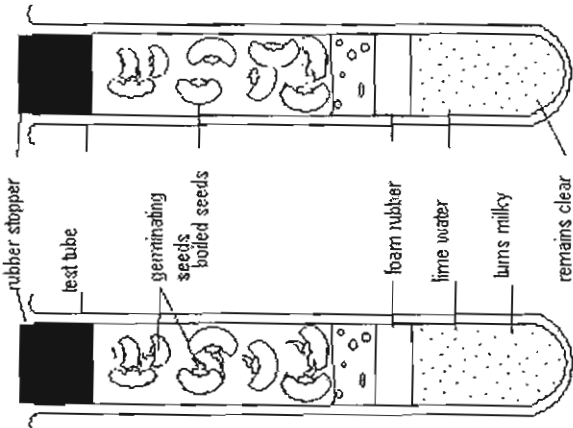
Energy and change Theme: Energy transfer

Topic	Teaching methods and strategies	Learning styles accommodated	Activities	Assessment task	Learning outcomes & assessment standards
Pressure	Exploration investigation (independent) Interactive Brainstorming Experimenting Oral presentation by learners Questioning	• Watchers • Thinkers • Sensors and Feelers • Doers	Ask learners to use a brick in 3 different positions (in groups) on wet sand. The bricks' three surfaces should be of different areas. Learners should record the different areas of the bricks.  Let them measure the depth at which the bricks sunk in the mud * Teachers can think of any simple investigations similar to this one. Let each group report their findings to the class (doers, sensors, feelers, thinkers) Explain the concept using the learners findings' i.e. pressure is force per unit area. Or pressure decreases as surface area increases. P	* Let learners calculate different pressures exerted individually (thinkers, watchers) (Give numerous problems to solve at home). Give them a reading assignment as well and ask them to report back to other learners in class (doers). Practical application questions such as : * Describe the process of sucking a drink, using a straw in terms of	LO1 ASs 1&2 LO2 AS 4 ,6,& 7

			= F/A (watchers, sensors and feelers)	pressure (thinkers) * Explain why a water reservoir's walls are thick at the bottom etc. (thinkers)	LO 3 AS 8
Pressure in liquids	Brainstorming Questioning Investigation Worksheets	Doers Watchers Thinkers Sensors & feelers	Use a plastic container full of water. Put the container on the table. Ask learners whether the water is exerting any pressure on the container. If it is, in which direction? (thinkers, doers, watchers, sensors and feelers) Give each group a container full of water and ask them to pierce the sides of the container (the container should be slightly suspended). Let them measure the distances the water reaches as the water level drops. Design a worksheet for this exercise (thinkers, doers, sensors, feelers) Explain that liquids exert pressure in all directions, as learners would have observed.	• Practical application (assignment). • Let learners find out how the following work (thinkers, doers, sensors, feelers) • A turbine • A hydraulic jack or lift (used to lift cars) • Car brakes	LO1 AS 1,2 & 3

Topic	Teaching method	Learning style	Activities				Assessment strategies	LOs & ASs
Energy transfer	Brainstorming Worksheets Chalkboard Library visit Notes	Thinkers Doers Sensors Feelers	Review Grade 8 work on types of energy. Ask learners to identify these types from a picture appliance e.g. Air conditioner, wood, electric bulb or kettle. They should also identify whether the energy is chemical, electrical, sound, heat or mechanical. Use a worksheet as follows : (thinkers, doers, sensors, feelers)				Let learners write a summary or definition or types and focus of energy (doers, thinkers, sensors, feelers, watchers)	
Energy transfer photosynthesis	Investigations Exploration Teacher explanation	Thinkers Doers Sensors and feelers Watchers	Object	Type of energy	Focus of energy	Use in daily life	Let learners give examples of each form of energy and how it is useful to society (thinkers, doers)	LO2 AS 4
			A					
			B					
			C					
			D					
			NB. This topic should be done after the plant and animal cell structure have been discussed. - Give learners different experiments to perform in groups to find the essentials of photosynthesis : - Two sets of green plants – one in light, the other in darkness. - One watered, the other unwatered. 2 sets of pot plants, one with and the other without a living rat: in each in a tightly closed jar.				Ask learners to draw a flow diagram of energy changes that occur in photosynthesis (watchers, doers)	LO1 AS 1&2 LO3 AS 7&8 LO 3 AS8

			4. 2 jars, one with green leaves, another with dead leaves, with a living rat in each. Leave these for a few days to a week and ask learners to record their observations. Discuss the results and explain the role of each substance. Keep referring to the plant cell poster that you will have displayed on the wall. 5. Discuss the importance of photosynthesis to animal life and the need to plant trees. (learners should do the above with reference to the jars containing rats in the above investigation) (doers, thinkers, sensors, feelers, watchers)		
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			The following experiment should be carried out to demonstrate that oxygen is released during photosynthesis and carbon dioxide is released during respiration (doers, watchers) Experiment:	LO1 AS's 1 2 & 3 LO2 AS 5 & 6
	To show that oxygen is released during photosynthesis		To show that carbon dioxide is released during respiration Discuss results of the above experiment and their complementary process in life (doers, sensors, feelers, watchers) Ask learners to make a poster to show negative effects of wild fires	Give learners a scenario: food digestion. Ask them to translate this either in the form of a diagram or verbal explanation written or orally (thinkers, doers, sensors, feelers, watchers) Debate/essay on: water is more important than the sun (thinkers, doers) Always include knowledge questions for the recall of information (watchers, sensors, feelers)

Topic	Teaching method and strategies	Learning styles	Activities	Assessment Tasks	Los & Ass
Electricity (static)	Experimentation	Thinkers	Revise types of electric changes (Grade 8 work) by referring to a spark one occasionally experiences when touching a metal door handle after walking on a carpeted floor. A comb as one combs one's hair. Do the following experiment to illustrate static electricity (doers, thinkers, watchers, sensors, feelers) Purpose: to generate static electricity Materials: rubber rods, glass rods, piece of silk, piece of flannel, piece of string and masking tape. Procedure : 1. Attempt to generate static electricity with the material provided. 2. Suspend one of the rubber rods from the corner of your desk, using the string and some tape. 3. With the suspended rod perfectly still, slowly bring the other rubber rod close to it. 4. Rub one of the rubber rods with the piece of silk and repeat step 3. 5. Rub both of the rubber rods with the piece of silk and repeat step 3. 6. Rub one rubber rod with silk and the other rubber rod with the piece of flannel and repeat step 3. 7. Repeat steps 2 to 6 using the glass rods. 8. Determine whether the objects attract or repel each other. 9. Describe each reaction making a diagram Use the worksheet below to record your results and answer the questions that follow in terms of your observations	* Recording of investigation * Reporting in writing and orally to class * Application questions such as: 1. Why do you hear a cracking sound when you touch the screen of a television set? (sensors, feelers, watchers, doers, thinkers) 2. What causes a person's hair to "stand on end" when he/she touches a Van de Graaff generator? (thinkers) Discuss energy transfers that occurs in the Van de Graaff generator (use any mode of communication the learner is most comfortable with) (thinkers, doers, sensors, feelers, watchers)	LO1 AS 1,2,& 3 LO 2 AS 5&6
	Teacher presentation	Doers			
	Investigation	Sensors and feelers			
	Oral presentation	Watchers			
	Flow charts				
	Learner demonstration				

			important)													
			<table border="1"> <tr> <td rowspan="2">OBJECTS TESTED</td> <td colspan="2">REACTION</td> </tr> <tr> <td colspan="2"></td> </tr> <tr> <td></td> <td>ATTRACT</td> <td>REPEL</td> </tr> <tr> <td></td> <td>(distance)</td> <td>(distance)</td> </tr> </table>	OBJECTS TESTED	REACTION					ATTRACT	REPEL		(distance)	(distance)		
OBJECTS TESTED	REACTION															
	ATTRACT	REPEL														
	(distance)	(distance)														
			Questions to be answered: Which techniques were most effective for generating static electricity? Did the distance between the objects make a difference? What do you predict would happen if you used a rubber rod and a glass rod in step 5 of the procedure? Try it. Discuss the results to explain the two types of charges namely negative and positive charges (watchers, thinkers) Use the Van De Graaff dome and the electroscope. The former to show effects of static electricity, the latter to detect the presence of static electricity (doers, sensors, feelers, thinkers, watchers) N:B Teachers should think of more interesting activities to illustrate this phenomena Explain the formation of static electricity charges in terms of removal of electrons from one atom to another. Refer to the atomic structure (thinkers, watchers)													
Current electricity	Exploration Brainstorming Demonstration	Doers Watchers Thinkers	Review Grade 8 work on current electricity Introduce the apparatus used to measure the amount of electricity that flows (Ammeter) and that measures stored electrical energy (Voltmeter). Give learners these gadgets.		LO 1 ASs 1,2,& 3 LO 2											

	Flow diagram Chalkboard Notes Worksheets	Sensors and feelers	Make sure they can read them properly. Let them use a voltmeter to read the voltage in a torch/ car / any available battery – Use torch batteries of different sizes (sensors, feelers, doers) Let learners connect bulbs in series on a circuit board and include the voltmeter and ammeter in the circuit. Let them manipulate them alone taking a few minutes before showing them how the voltmeter and ammeter are correctly connected a voltmeter in parallel and an ammeter in series. Let them brainstorm why these two are connected in this way. Let them make a diagram of the connection in their own workbooks. Design a work sheet for this activity for learners, connect the bulbs in parallel and use a similar worksheet to record the observation. Compare the results in groups. Use the same circuit arrangements as above, but introduce the following items as part of the circuit: iron strip, copper and glass. Design a worksheet for learners for this activity. 	Investigations: -planning (thinkers) -conducting (doers, sensors, feelers, thinkers, watchers) -recording (watchers, thinkers) -reporting (doers) -interpreting (thinkers) Drawing the diagram (watchers, doers) Making a flow chart (watchers, doers) Explaining the processes, either in writing or by means of a flow diagram (thinkers, doers, watchers)	AS 6
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Topic	Teaching method	Learning style	Activity	Assessment tasks	LO & AS																								
			Worksheet : Example	- Learners plan, conduct, record and report findings of an investigation (thinkers, doers, sensors, feelers, watchers) - Learners interpret these findings (thinkers) - Learners predict what would happen if more cells were added to the circuit, if the length of the resistor was increased and confirm their predictions through experimentation (thinkers, doers, sensors) - Learners find out about use of circuit breakers and resistors in daily life, especially in a home (doers, thinkers) - Give learners a verbal procedure of how an electric stove functions. Ask them to translate this into a diagram (sensors, feelers, watchers)	LO 1																								
			<table><tr><td>Circuit series</td><td>Voltage reading</td><td>Ammeter reading</td><td>a/b</td></tr><tr><td>Normal</td><td></td><td></td><td></td></tr><tr><td>Circuit</td><td></td><td></td><td></td></tr><tr><td>Iron ship</td><td></td><td></td><td></td></tr><tr><td>Glass</td><td></td><td></td><td></td></tr><tr><td>Circuit in parallel</td><td></td><td></td><td></td></tr></table>		Circuit series	Voltage reading	Ammeter reading	a/b	Normal				Circuit				Iron ship				Glass				Circuit in parallel				ASs 1 2 & 3
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Iron ship																													
Glass																													
Circuit in parallel																													
			- Discuss, explain a/b as resistance (watchers, thinkers) - Let learners draw a graph of their result of a/b for both arrangements (watchers, doers) - Introduce the relationship between voltmeter and ammeter reading to current flows (watchers, sensors, feelers) - Show learners a model/ sketch of wiring a home (watchers, sensors, feelers) - Let them make their own sketch and explain it in terms of series or parallel connection, voltage, etc. (watchers, doers)	LO 2																									
				ASs 5& 6																									
				LO3																									
				AS 8																									

				Give lower order questions such as; match column a & b; fill in the missing word; define.....or a diagram with questions based on it.							
			Let learners identify which household appliance uses the most electricity, using this grid:	- Ask learners to role-play discuss, write ways they think could be used to preserve electricity at home or let them come up with cheaper alternatives. - Learners translate the solar system as discussed into a poster concept map or a model with a full explanation of the functions and all the energy changes that occur. - Learners draw the magnetic fields of all the positions. - Explain the similarities or differences in the shape of magnetic fields.	LO 3 AS 8 & 9						
	Field trips	Watchers	<table><tr><th>Appliance</th><th>Time on</th><th>Meter reading</th></tr><tr><td colspan="3"> - Explain how electricity is costed and ask them to bring their electricity bills to illustrate the point (watchers, doers, sensors, feelers) - Discuss the solar system (sensors, watchers) - Discuss appliances of energy transfer in generating electricity e.g Eskom, Eveready batteries, car batteries (sensors, watchers). Take a trip to these places. - Discuss career paths that emanate from this knowledge. - Display different types of magnets, such as a horse-shoe magnet a bar magnet and an electromagnet. Let learners play around with these. Let learners brainstorm similarities of substances that conduct or do not conduct electricity and those that are magnetic or non-magnetic (doers, sensors, feelers, thinkers) - Let learners pair magnets parallel to one another with same poles in same directions. Cover with paper sheet and sprinkle iron filings. Let them draw diagrams of two positions. Do the same exercise with a horse-shoe magnet. Discuss the results, using a large poster of the same position to make explanation easier and meaningful (thinkers, doers, sensors, feelers, watchers) </td></tr></table>	Appliance	Time on	Meter reading	- Explain how electricity is costed and ask them to bring their electricity bills to illustrate the point (watchers, doers, sensors, feelers) - Discuss the solar system (sensors, watchers) - Discuss appliances of energy transfer in generating electricity e.g Eskom, Eveready batteries, car batteries (sensors, watchers). Take a trip to these places. - Discuss career paths that emanate from this knowledge. - Display different types of magnets, such as a horse-shoe magnet a bar magnet and an electromagnet. Let learners play around with these. Let learners brainstorm similarities of substances that conduct or do not conduct electricity and those that are magnetic or non-magnetic (doers, sensors, feelers, thinkers) - Let learners pair magnets parallel to one another with same poles in same directions. Cover with paper sheet and sprinkle iron filings. Let them draw diagrams of two positions. Do the same exercise with a horse-shoe magnet. Discuss the results, using a large poster of the same position to make explanation easier and meaningful (thinkers, doers, sensors, feelers, watchers)				
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	Library visits	Doers									
	Lecturing	Thinkers									
	Chalkboard										
	Brainstorming	Sensors and feelers									
	Worksheets										
	Experimenting										
	Oral presentation				LO 1 AS 1 ,2 &3						

			Learners brainstorm energy changes that have occurred, starting with the battery that supplies the electricity (watchers, thinkers)	Let learners speculate on the reasons for the structure of magnetic fields (refer them to negative & positive charges of electricity). This could be done in writing or verbally (watchers, doers, thinkers)	LO 1 AS 1,2,& 3
The plotting compass and the dynamo	Exploration Investigation Lecturing Brainstorming Demonstration by teacher	Watchers Sensors and feelers Doers Thinkers	Learners play around with bar magnets and plotting compasses. They brainstorm their observation. Discuss these observations and the uses of the plotting (Mariner's compass). Refer to the earth's magnetic south and north poles. Give learners the resources to make their own plotting compasses. (thinkers, doers, watchers, sensors, feelers) - Introduce the concept dynamo by demonstrating the effects of magnetic field lines that cut across a wire conducting electricity (sensors, watchers) - When giving tasks, always include a few knowledge questions, as knowledge of facts and concepts is prerequisite to application and integration.	- Learners are tasked to look up Michael Faraday and write short notes on his discoveries (sensors, doers) - Learners make their own plotting compasses (doers) - Identify differences between a solenoid and a dynamo. Ask learners to explain (with the aid of a diagram or model) how the following work: a door bell, hair- dryer, an electric fan, telephone, vacuum cleaner etc. (This is done in groups, with each group using one appliance) (doers,thinkers)	LO 3 AS 8 LO 2 AS7

CHAPTER SEVEN

SUMMARY, FINDINGS AND RECOMMENDATIONS

7.1 INTRODUCTION

In this chapter, the researcher endeavours to revisit the aims of the study in order to ascertain whether it has been achieved. Some problem questions were posed in the opening chapter of this study. These needed to be answered as the study unfolded.

The researcher's task in this chapter is to check whether the literature review as well as the questionnaires that were administered contributed in answering the problem questions on which the study were based.

The layout of this chapter is as follows:

- Overview of the study
- Findings from the literature review
- Findings from the empirical research
- Findings in relation to the aims of the study
- Recommendations

7.2 OVERVIEW OF THE STUDY

This section intends to provide a brief overview of all the previous chapters of this study. The purpose of this exercise is to focus the reader's mind on the important aspects of each chapter, so that the findings and the recommendations that ensue here after make a meaningful link.

7.2.1 Chapter one

The purpose of this chapter was to orientate the reader to the following:

- The problem statement, which is whether teaching and assessment of the Natural Sciences takes cognizance of the diversity of learners' learning styles.
- The aim of the study, namely to improve on the effectiveness of teaching and learning the Natural Sciences.
- The design of the research.
- Defining technical terms that are used in the study.
- The structure of the study.

7.2.2 Chapter two

This chapter delved deep into literature pertaining to teaching methods, teaching strategies, learning styles and assessment. Theories underlying teaching, learning and assessment were expatiated upon. Methods of teaching and assessment strategies were explored. Although the literature review exposed a variety of teaching methods and strategies, it was indicated that all these fall under four major teaching methods, namely Direct Instruction, Indirect Instruction, Independent Instruction and the Interactive teaching methods (*cf* 2.3.2.2, 2.3.2.2, 2.3.2.3, 2.3.2.4). The National Curriculum Statement recommends the last two teaching methods for the Natural Sciences (*cf* 2.3.2.3, 2.3.2.4). Learning styles in general were also discussed, but four learning styles which encompass all the learning styles and learning modes were cited as thinking, feeling, doing and watching (*cf* 2.4).

Assessment and assessment strategies were discussed and the following six types of assessment were identified: baseline, formative, summative, norm-referenced, criterion-referenced and performance based types of assessment.

7.2.3 Chapter three

This chapter served to outline the nature of the Natural Sciences. It was found to be empirical, analytic, tentative and stable, of public knowledge and replicable by nature. The Natural Sciences National Policy was introduced in detail in this chapter.

A link between the teaching styles/methods, assessment strategies and learners' learning styles most applicable for teaching the Natural Sciences was made. Although there is no best method for teaching science to all children, this research study tried to link teaching methods/strategies to diverse learning styles (*cf* 3.4) in order to support the policy of inclusion during teaching and learning (*cf* 1.1).

Assessment strategies prescribed by the National Curriculum Statement for the Natural Sciences were highlighted.

7.2.4 Chapter four

The aims of the research and the research methodology were specified and the procedures for conducting the study were outlined.

7.2.5 Chapter five

Data collected through the use of questionnaires was analysed and interpreted in this chapter. The findings indicated that teachers experience problems in accommodating diverse learning styles in the teaching of the Natural Sciences.

7.2.6 Chapter six

The focus of this chapter is the teaching and learning programme which is in the form of guidelines. These guidelines suggest ways of linking teaching styles, teaching methods, assessment strategies, learning outcomes and assessment strategies to learners' learning styles in the teaching of the Natural Sciences in Grade 9.

7.3 FINDINGS FROM THE LITERATURE REVIEW

7.3.1 Teaching Methods

The literature review suggests that teaching methods most appropriate for the teaching of the Natural Sciences are Indirect Instruction and Interactive Instruction (*cf* 2.3.2.3, 2.3.2.4). The other two, that is, Direct Instruction and Independent Instruction should be used sparingly (*cf* 2.3.2.1, 2.3.2.1).

7.3.2 Teaching styles

Outcomes-Based Education recommends the facilitation teaching style, which is learner centered. The transmission/reception teaching style- which is teacher centered-should be used minimally (*cf* 2.3.1.1).

7.3.3 Learning Styles

Although there are a variety of learning styles, it is suggested that whatever a learning style or learning mode a learner uses, learning is done through doing, feeling, thinking or watching (*cf* 2.4). These four modes of learning are regarded as the umbrella of all the learning styles and should be visible in all teaching (*cf* 2.4.10).

7.3.4 Assessment Strategies

Quite a number of assessment strategies were discussed, but important were those that are prescribed for assessing outcomes in the Natural Sciences. The National Curriculum Statement prescribes the following assessment strategies for the Natural Sciences (*cf* 3.5).

- Investigations/projects
- Assignments
- Tests and examinations
- Presentations
- Translation tasks

7.4 FINDINGS FROM THE EMPIRICAL RESEARCH

7.4.1 Teaching methods

Findings from the questionnaires to teachers and learners about the most used teaching methods revealed the following:

- That the teaching methods which are mostly used are: questioning, presentation by teacher and demonstration by teacher (*cf* 5.2.3). These are all clustered under the Direct Instruction method of teaching (*cf* 2.3.2.1, 5.2.3).
- That the least used teaching methods are: field trips, surveys, designing, crossword puzzles, and concept maps (*cf* 5.2.3).

The teaching methods which are least used are those recommended for the teaching of the Natural Sciences according to the literature review (*cf* 2.3.2.2, 2.3.2.3, 2.3.2.4, 3.4).

These findings do not support the information obtained from the literature review where it is indicated that the choice of methods should accommodate the diverse needs of all learners (*cf* 2.3.2).

7.4.2 Teaching styles

The data analysis revealed that both the facilitation teaching style and the transmission teaching style were used equally during teaching time (*cf* 5.2.2). Contrary to this finding, the analysis also revealed that teacher and learner responses indicate the use of the Direct Instruction method and the transmission style of teaching. It is recommended by the literature that transmission and reception as well as facilitation should be balanced (*cf* 2.3.1.2).

7.4.3 Assessment strategies

The assessment strategies which are preferred by teachers are assignments and those which require learners to provide to-the-point information and tests and examinations (*cf* 5.2.5). This is in contrast with what the literature review

indicates, namely that for the Natural Sciences there should be a strong focus on investigations and projects (*cf* 6.1.8).

7.4.4 Problems encountered by teachers and learners

More than half the teachers lack knowledge of learning styles, assessment approaches and assessment strategies, skills to link teaching methods to learning styles to achieve learning outcomes and the skills to use assessment to determine whether the outcomes have been achieved. Furthermore there is a need for in-service training to assist teachers in dealing with the problems encountered. (*cf* 5.2.6). Most of the learners experience a problem of too many concrete activities and not enough time to do things on their own (*cf* 5.2.7). These findings link well with the indication given by teachers of their poor qualifications and limited experience in teaching the subject (*cf* 5.2.1.1).

7.5 FINDINGS IN RELATION TO THE AIMS OF THE STUDY

This study aimed at unearthing facts about the following aspects which tabled as they are listed in chapter one, and immediately followed by the statement that explains whether the aim has been accomplished or not.

- **Aim 1:** To establish how well diverse learning styles are addressed in the teaching of the Natural Sciences at secondary school level.

This was attained through teachers' responses to the questionnaire. It was discovered that a large number did not know how to link learning styles to learning outcomes (*cf* 5.2.6). Teaching methods which are favoured by teachers are questions, presentations by the teacher, demonstrations by the teacher and worksheets. The first three teaching strategies favour "watchers", while the latter favours "doers." It becomes apparent, therefore, that diversity is not properly addressed as the majority of learners in the sample were sensors and feelers (*cf* 5.2.4).

It appears as if diverse learning styles are not addressed effectively as envisaged by the policy documents of the Department of Education in which the focus is on inclusive education (*cf* 2.3.2)

- **Aim 2:** To determine whether educators are skilled enough to address learning style diversity in the teaching of the Natural Sciences competently and effectively at secondary school level and to determine the availability of support and assistance to educators of the Natural Sciences to cope with learning style diversity in the teaching of the Natural Sciences at secondary school level.

All the guideline documents from the Department of Education, whether National or Provincial, advise teachers to be mindful of learners' learning styles. This is a principle generic to teaching Outcomes-Based Education, irrespective of the learning area. A closer examination of these documents indicates that teachers are not provided with the skills and knowledge of **how** to incorporate this in teaching and learning. The training manuals are plentiful but fall short when it comes to the practical aspect.

Teachers' responses to the questionnaire reveal that most teachers indicated that they lack knowledge of learning styles, assessment approaches, planning, linking learning styles to learning outcomes and the use of assessment strategies to achieve outcomes (*cf* 5.2.6). This scenario implies that the Natural Sciences teachers do not have sufficient skills to address learning style diversity in the classroom.

- **Aim 3:** To develop a teaching and learning programme that guides teachers on how to link teaching intentions and learning outcomes to learning styles in order to improve the quality of teaching the Natural Sciences at secondary school level.

The programme has been developed in Chapter 6.

7.6 RECOMMENDATIONS

In view of the findings of this study, the researcher recommends the following:

7.6.1 Teaching methods

Teachers should become versatile in their teaching as to accommodate a variety of learning styles. Direct Instruction, Indirect Instruction, Independent

Instruction and Interactive Instruction should be utilized during teaching. Especially in the Natural Sciences a strong focus should be on Independent and Interactive Instruction methods of teaching (*cf* 2.3.2.2, 2.3.2.3, 2.3.2.4). The inclusion of different teaching methods is necessary to accommodate diverse learning styles and to comply with the inclusion policy of the Department of Education (*cf* 1.1).

7.6.2 Teaching styles

Teachers should make use of the facilitation style more than the transmission style, as the former is the preferred style of teaching for Outcomes-Based Education (*cf* 2.3.1.2). This teaching style involves learners actively in the teaching and learning process, which is important for the Natural Sciences. It should however not be forgotten that the transmission style of teaching should also be accommodated as this style addresses the learning style needs of learners who prefer to learn through sensing, feeling and watching (*cf* 3.5).

7.6.3 Learning styles

Teachers have to improve on their knowledge of learning styles so that they are better positioned to identify the type of learners they have in the classroom. This facilitates teaching and learning because knowledge of learners' preferred learning styles directs teaching to make it more meaningful and effective (*cf* 2.4.10).

7.6.4 Assessment strategies

Teachers should use a variety of assessment strategies in order to address the diversity of learning styles (*cf* 2.4.10, 3.5, 6.1.9). It is also imperative that a stronger focus should be placed on assessment strategies applicable for the Natural Sciences (*cf* 6.1.8).

Other recommendations include the following:

- Further work should be done on the programme designed to cover all the knowledge strands in order to support the teachers fully.

- In-service training should be focused on this important aspect of linking teaching methods and assessment strategies to the learning styles of learners. Training manual should however not focus on theory alone, but provide teachers with the “know-how” of linking teaching to diverse learning styles.
- Teachers themselves should make an effort to improve their knowledge of learning styles and how these affect learning in general and in the Natural Sciences specifically.

7.7 CONCLUSION

In view of the limitations mentioned earlier (*cf* 4.10), it is hoped that further research will be conducted on this topic. Teaching and learning of the Natural Sciences and related subjects like Technology calls for a concerted effort from all stakeholders.

The Natural Sciences is a unique field with unique features. Teachers have to have full control of knowledge or content as well as skills, in order to be able to teach the Natural Sciences in the manner prescribed by the NCS. The researcher is of the opinion that a teacher of the Natural Sciences needs to possess qualities such as patience, creativity, and a passion for knowledge regarding the subject matter as well as knowledge regarding various teaching methods, learning styles and assessment strategies in order to facilitate the learning process effectively. This is challenging and time-consuming but can also be very fulfilling if done in the right way.

Knowledge and mastery of the Natural Sciences are gateways to technology and dominant forces in civilization. It needs no academic debate to fathom that the teaching and learning of the Natural Sciences in this country are in dire straits. Sustained and purposeful efforts are needed to put it on track.

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ADDENDUM A

Questionnaire to the senior phase Natural Sciences teachers in the Lejweleputswa District in the Free State Province

The purpose of this study is to determine the effectiveness of teaching in the Natural Science Senior phase in an inclusive setting.

The study is undertaken for academic purposes only and the results will not be used against you or your school. All information will be treated confidentially and anonymous. Feel free to answer all the questions without fear of being victimized.

It is my humble request that you provide your answers as truthfully and honestly as possible.

Thank you for your co-operation.

Mrs. R. Maja

Questionnaire to Teachers

This questionnaire consists of six sections. Please make sure that you respond carefully to all of the questions in each section.

The aim of the questionnaire is to determine:

- the biographical status of the teachers
- the teaching styles most often used by teachers
- what teaching methods teachers often use
- whether teachers accommodate learners' learning styles when teaching
- what assessment strategies teachers use
- what problems teachers experience during the teaching of the Natural Sciences

Section 1: Biographical information

1. Indicate your highest academic qualification with an X in the appropriate block.

1.1	Grade 10	
1.2	Grade 12	
1.3	Bachelor's degree	
1.4	Honours degree	
1.5	Masters degree	
1.6	PhD	

2. Indicate your highest professional qualification with an X in the appropriate block.

2.1	One year education diploma/certificate	
2.2	Two year education diploma/certificate	
2.3	Three year education diploma/certificate	
2.4	Four year education diploma/certificate	
2.5	Postgraduate education diploma/certificate (HED)	

3. Indicate your number of years teaching experience. Indicate your choice with an X in the appropriate column.

3.1	1-5 years	
3.2	6-10 years	
3.3	11-15 years	
3.4	16- 20 years	
3.5	More than 20 years	

Section 2: Teaching styles

4 Indicate the % of time which you normally spend using the following teaching styles. Indicate your choice by marking with an X in the appropriate block.

4.1 Transmission reception style: teacher talks most of the time. Lectures, explanations and demonstrations.

Less than 10%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

4.2 Facilitation style: learner involvement, discovery and inquiry

Less than 10%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Section 3: Teaching methods.

5 Indicate how often the following teaching methods are utilised during your teaching.

Indicate your choice by marking with an X in the appropriate block.

	Always	Often	Sometimes	Never
5.1 Lectures				
5.2 Drilling				
5.3 Worksheets				
5.4 Presentations by teacher				
5.5 Demonstrations by teacher				
5.6 Constructing concept maps				
5.7 Case studies				
5.8 Making posters				
5.9 Oral presentations by learners				
5.10 Role plays				
5.11 Designing				
5.12 Projects				
5.13 Field trips				
5.14 Experimenting				
5.15 Questioning				
5.16 Debates				
5.17 Surveys				
5.18 Crossword puzzles				
5.19 Co-operative learning				
5.20 Demonstrations by learners				
5.21 Brainstorming				

Section 4: Learning styles

6. Indicate how often the following 4 major learning styles are accommodated through your teaching. Indicate your choice by marking with an X in the appropriate block.

	Always	Often	Sometimes	Never
6.1 Sensors and feelers: learners who like to see, hear and feel in order to learn.				
6.2 Watchers: learners who like to learn through perception and observation. They like lectures and demonstrations.				
6.3 Thinkers: learners who like to analyse and create understanding for themselves. They like to read theory and study well by themselves.				
6.4 Doers: learners who prefer practice to theory. They like doing projects.				

Section 5: Assessment strategies

7 Indicate how often learners are exposed to the following variety of assessment opportunities. Indicate your choice by marking with an X in the appropriate block.

	Always	Often	Sometimes	Never
7.1 Analysing				
7.2 Synthesizing				
7.3 Planning				
7.4 Providing precise, to-the-point information				
7.5 Discovering and exploration				

7.6 Experimenting				
7.7 Practical applications				
7.8 Group discussions				
7.9 Action, moving around				
7.10 Research				
7.11 Investigations				
7.12 Assignments				
7.13 Tests/Exams				
7.14 Presentations and performances				
7.15 Translation tasks: graphs, diagrams, mind maps				

Section 6: Problems encountered during the teaching of Natural Science.

8 Indicate whether the following aspects are problematic during the teaching of the Natural Sciences. Indicate your choice by marking with an X in the appropriate block.

	Yes	No
8.1 Lack of knowledge about teaching styles		
8.2 Lack of knowledge about teaching methods		
8.3 Lack of knowledge about learning styles		
8.4 Lack of knowledge about assessment approaches		
8.5 Lack of knowledge about assessment strategies		
8.6 Lack of knowledge regarding the variety of learning activities to utilize during teaching and learning.		
8.7 Lack of skills and knowledge in planning for and designing learning programmes		

8.8 Lack of support and assistance in planning for and designing learning programmes		
8.9 Lack of skills regarding how to link the correct teaching method to a specific learning outcome and learning content		
8.10 Lack of skills regarding how to link the various learning styles to the attainment of a specific learning outcome.		
8.11 Lack of skills regarding how to utilize the various assessment strategies to determine the attainment of a specific learning outcome.		
8.12 Lack of skills regarding how to utilize various learning activities to assist learners to attain learning outcomes.		
8.13 Lack of in-service training programmes to reinforce knowledge and skills regarding teaching and learning.		

ADDENDUM B

Questionnaire to learners doing Natural Science in the Senior phase in the Lejweleputswa District (Free State Province)

The purpose of this study is to determine the effectiveness of teaching in the Natural Science Senior phase in an inclusive setting.

The study is undertaken for academic purposes only and the results will not be used against you or your school. All information will be treated confidentially and anonymous. Feel free to answer all the questions without fear of being victimized.

It is my humble request that you provide your answers as truthfully and honestly as possible.

Thank you for your co-operation.

Mrs. R. Maja

The questionnaire consists of six sections. Please make sure that you respond carefully to all the questions in each section.

The aim of the questionnaire is to determine:

- your biographical status;
- the teaching styles mostly used by your teachers;
- the teaching methods mostly used by your teachers;
- your preferred learning style;
- the assessment strategies your educators use mostly;
- the problems you encounter during the teaching of Natural Science; and
- your achievement level in Natural Science

Questionnaire to Learners

Section 1: Biographical information

1. Please indicate your age by marking with an X in the appropriate block.

1.1	11	
1.2	12	
1.3	13	
1.4	14	
1.5	15	
1.6	16	
1.7	17	
1.8	18	
1.9	19	
1.10	20	
1.11	Older than 20	

2. Indicate your final percentage pass in Natural Science for the following grades by marking with an X in the appropriate block.

Grade	10-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
6									
7									
8									

Section 2: Teaching styles

3. Indicate the % of time that your Natural Science teacher normally spends using the following teaching styles. Indicate your choice by marking with an X in the appropriate block.

3.1 Transmission reception style: teacher talks most of the time. Lectures, explanations and demonstration.

Less than 10%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

3.2 Facilitation style: learner involvement, discovery and inquiry

Less than 10%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Section 3: Teaching methods.

4. Indicate how often your Natural Science teacher utilizes the following teaching methods during teaching. Indicate your choice by marking with an X in the appropriate block.

	Always	Often	Sometimes	Never
4.1 Lectures				
4.2 Drilling				
4.3 Worksheets				
4.4 Presentations by teacher				
4.5 Demonstrations by teacher				
4.6 Constructing concepts maps				
4.7 Case studies				
4.8 Making posters				
4.9 Oral presentations by learners				
4.10 Role plays				
4.11 Designing				
4.12 Projects				
4.13 Field trips				
4.14 Experimenting				
4.15 Questioning				
4.16 Debates				
4.17 Surveys				
4.18 Crossword puzzles				
4.19 Co-operative learning				
4.20 Demonstrations by learners				
4.21 Brainstorming				

Section 4: Learning styles

5. Indicate your preferred learning style. Only indicate the style you favour the most. Indicate your choice by marking with an X in the appropriate block.

	Preferred learning style
5.1 Sensors and feelers: learners who like to see, hear and feel in order to learn.	
5.2 Watchers: learners who like to learn through perception and observation. They like lectures and demonstrations.	
5.3 Thinkers: learners who like to analyse and create understanding for themselves. They like to read theory and study well by themselves.	
5.4 Doers: learners who prefer practice to theory. They like doing projects.	

Section 5: Assessment strategies

6. Indicate how often you are exposed to the following variety of assessment opportunities. Indicate your choice by marking with an X in the appropriate block.

	Always	Often	Sometimes	Never
6.1 Analysing				
6.2 Synthesizing				
6.3 Planning				
6.4 Providing precise, to-the-point information				
6.5 Discovering and exploration				
6.6 Experimenting				

	Always	Often	Sometimes	Never
6.7 Practical applications				
6.8 Group discussions				
6.9 Action, moving around				
6.10 Research				
6.11 Investigations				
6.12 Assignments				
6.13 Tests and exams				
6.14 Presentations and performances				
6.15 Translation tasks: graphs, diagrams and mind maps				

Section 6: Problems encountered during the teaching of the Natural Sciences

7. Indicate whether the following are problems which you as a learner experience during the teaching of the Natural Sciences.

	Yes	No
7.1 Too many concrete experiences: see, hear and feel in order to learn.		
7.2 Too many lectures, explanations and demonstrations.		
7.3 Too much reading and finding out things for myself.		
7.4 Too much practice, doing projects.		
7.5 Too many abstract experiences.		
7.6 Not enough lectures, explanations and demonstrations		
7.7 Not enough time to do things on my own.		
7.8 Too much co-operative group work.		

ADDENDUM C

LETTER FROM THE EDUCATION DEPARTMENT

For Attention:

Mr WB van Rooyen

School of Educational Sciences

Tel (016) 016 910 3683

Fax (016) 016 910 3715

Free State Department of Education

5 July 2004

Private Bag X20565

Bloemfontein

9200

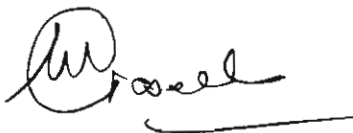
Dear Sir

DOCTORAL STUDIES: RM MAJA (STUDENT NUMBER: 131970882)

I hereby confirm that the above mentioned student is currently registered at the North-West University (Vaal Triangle) for her doctoral thesis: **A PROGRAMME TO TEACH NATURAL SCIENCES EFFECTIVELY AT SECONDARY SCHOOLS LEVEL IN AN INCLUSIVE SETTING**. The undersigned will act as her promoter.

We trust that her application to conduct research will be granted.

Yours sincerely



Dr M Grosser
Senior Lecturer: Teaching and Learning

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FREE STATE PROVINCE



Enquiries : Mrs M V Wessels/
Reference no. : 16/4/139-2004

Tel : (051) 404 8075
Fax : (051) 4048074

2004-07-16

Ms R Maja
13 Camilla Street
Riebeeckstad
9469

Dear Ms Maja

REGISTRATION OF RESEARCH PROJECT

1. This letter is in reply to your application for the registration of your research project.
2. Research topic: **A programme to teach Natural Sciences effectively at secondary school level in an inclusive setting.**
3. Your research project has been registered with the Free State Education Department and you may conduct research in the Free State Department of Education under the following conditions:
 - 3.1 Learning facilitators, principals, educators and learners participate voluntarily in the project.
 - 3.2 The names of all schools, learning facilitators, principals, educators and learners involved remain confidential.
 - 3.3 The questionnaires are completed outside normal tuition time.
 - 3.4 You consider making the suggested changes.
 - 3.5 This letter is shown to all participating persons.
4. You are requested to donate a report on this study to the Free State Department of Education. It will be placed in the Education Library, Bloemfontein. It will be appreciated if you would also bring a summary of the report on a computer disc, so that it may be placed on the website of the Department.
5. Once your project is complete, you will be invited to present your findings to the relevant persons in the FS Department of Education. This will increase the possibility of implementing your findings wherever possible.
6. You are requested to confirm acceptance of the above conditions in writing to:

The Head: Education, for attention: CES: IRRISS
Room 1204, Provincial Government Building
Private Bag X20565, BLOEMFONTEIN, 9301

6. We wish you every success with your research.

Yours sincerely


Director: ICT and IRRISS

cc Director of District: Lejweleputswa

Department of Education ∇ Departement van Onderwys ∇ Lefapha la Thuto

13 Camilla Street
Riebeeckstad
9469
Cell: 0828573068

The Principal

..... Secondary school

Dear Sir/Madam,

Please grant me permission to undertake a research study at your school with effect from the beginning of august 2004.

The purpose of the study would be to investigate whether the currently used methods in the teaching of the Natural Sciences meet the prescripts of OBE and The Revised National Curriculum Statements and subsequently devise a model that will assist Natural Sciences teachers , should it be found that there is need for such.

The study will be conducted in a normal setting, as this is an action research, therefore normal teaching will not be interfered with.

I would appreciate it if you could inform your Natural Sciences teachers of this intent. The target group would be the Grade 9 learners.

Permission has been granted to me to carry out this project -as per the attached letter- and the information given will be treated with utmost confidentiality and anonymity.

You cooperation in this regard will be highly appreciated .

Regards,

Relebohile Maja (researcher)

Date-----