THE VALUE, PLACE AND METHOD OF TEACHING NATURAL SCIENCE IN THE FOUNDATION PHASE

by

LINDA BOSMAN

submitted in fulfilment of the requirements for the degree of

MASTER OF EDUCATION

in the subject

DIDACTICS

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: DR. C.J.S. VAN STADEN

MARCH 2006

THE VALUE, PLACE AND METHOD OF TEACHING NATURAL SCIENCE IN THE FOUNDATION PHASE

ABSTRACT

The study aims at establishing whether Foundation Phase schooling provides a proper foundation for the promotion of scientific literacy. Natural Science in the Foundation Phase is understood as scientific knowledge, process skills, and values and attitudes, which *together* should foster scientific literacy. Influential perspectives on learning, and teaching methods appropriate to Natural Science education in the Foundation Phase, are reviewed, and the Natural Science Learning Area in the RNCS discussed in the context of global trends in curriculum development. Finally the findings of an empirical survey on the perceptions of Foundation Phase teachers with regard to Natural Science teaching and learning, are presented.

Major findings include the following: (1) Scientific literacy is currently not a curriculum priority in the Foundation Phase, due mainly to meagre time allocation and lack of applicable Learning Outcomes. (2) Although teachers appear predominantly positive towards the Learning Area, significant shortcomings need to be addressed before Natural Science teaching in the Foundation Phase may claim to provide the required basis for promoting scientific literacy.

KEY TERMS

Natural Science, Scientific literacy, Scientific knowledge (concepts), Scientific process skills, Scientific values and attitudes, Foundation Phase, Outcomes-based education, Integrated curriculum, Constructivist perspective, Teaching methodologies.

OPSOMMING

Die studie poog om vas te stel of Grondslagfase-onderrig ‘n geskikte basis lê vir die bevordering van wetenskaplike geletterdheid. Natuurwetenskappe in die Grondslagfase word beskou as ‘n kombinasie van wetenskaplike kennis, prosesvaardighede, en waardes en ingesteldhede, wat gesamentlik wetenskaplike geletterdheid ten doel het. Invloedryke perspektiewe op leer, en gepaste onderrigmetodes vir die effektiewe fasilitering van Natuurwetenskappe-onderrig in die Grondslagfase word onder die loep geneem voordat die Natuurwetenskappe-leerarea in die Hersiene Nasionale Kurrikulumverklaring bespreek word binne die konteks van wêreldwye neigings in kurrikulumontwikkeling. Laastens rapporterr die studie die bevindinge van ‘n empiriese ondersoek na die persepsies van Grondslagfase-onderwysers rakende Natuurwetenskaponderrig en -leer.

Belangrike bevinding sluit in: (1) Die bevordering van wetenskaplike geletterdheid word nie as kurrikulumprioriteit in die Grondslagfase beskou word nie, soos blyk uit die karige toedeling van tyd en aantal leeruitkomste aan die Natuurwetenskappe-leerarea op hierdie vlak. (2) Alhoewel onderwysers se persepsies rakende Natuurwetenskap-onderrig en -leer oorwegend positief blyk te wees, is daar ernstige tekortkominge wat aangespreek moet word voordat Natuurwetenskappe-onderrig in die Grondslagfase die vereiste grondslag sal kan lê vir die bevordering van wetenskaplike geletterdheid.

Trefwoorde

Natuurwetenskappe, Wetenskaplike geletterdheid, Wetenskaplike kennis (konsepte), Wetenskaplike prosesvaardighede, Wetenskaplike waardes en ingesteldhede, Grondslagfase, Uitkomsgebaseerde onderwys, Geïntegreerde kurrikulum, Konstruktiwistiese perspektief, Onderrigmetodes.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude and appreciation to the following people who have been supportive and influential in accomplishing this study:

- Dr Christie van Staden, for her role as my supervisor, but also as my mentor and role-model.
- The Gauteng Department of Education (Tshwane-North and South) who granted permission to administer the questionnaires in the schools under their jurisdiction.
- The principals, but in the particular, the Foundation Phase teachers who took part in the empirical survey.
- Dr. Esmé Prinsloo, dr. Linda Fouché and students of the University of Pretoria for their help with the distribution of the questionnaires.
- Heléne Muller of the Research Support Unit (UNISA Computer Services) for her assistance in the data analysis.
- Martjie Bosman for the language editing of the dissertation.
- Friends and family (near and far) for their moral support and encouragement.
- My children Charlotte, Rudolph and Frederik for their understanding, patience and love.
- My greatest thanks must be reserved for my husband, Phlip, whose ongoing support, encouragement and sympathetic comments sustained my efforts to conduct this study.

CONTENTS

CHAPTER 1: ORIENTATION

LIST OF TABLES

LIST OF DIAGRAMS

CHAPTER 1

ORIENTATION

1.1 INTRODUCTION

> *"Every normal infant is born with natural mathematical and scientific abilities. That there are only a few specialist scientists on the planet is NOT because they are rare geniuses (although some certainly are), but because we neglect to develop our inherent potential. Maths, science and technology is about you, is an integral part of you. YOU are a natural scientist ..."*
>
> Dr Bob Day, Chairperson, Sasol SciFest 2003

Science has become an increasingly prominent factor in our understanding of the world, and in improving the quality of our lives. Scientific literacy is also increasingly important in the workplace. The rapid pace of technological change and the globalisation of the marketplace have resulted in the need for individuals with a broad general education, good communication skills, adaptability and commitment to lifelong learning (Goodrum, Hackling and Rennie 2001). People are required to think critically, to solve problems and to use technology effectively. A technology-driven environment depends on a scientifically literate public.

However, the question arises, whether education in the 21st century provides individuals with sufficient knowledge and understanding to follow scientific debates with interest, and to engage in an informed way with the many social and individual issues posed by science and technology. This question is a concern in many countries. According to Millar and Osborne (in Goodrum, Hackling and Rennie 2001), without a fundamental review and consideration of the aims and content of the science curriculum, what is offered to young people today is in danger of becoming increasingly irrelevant both to their needs and to that of society. The concern has generated an enormous increase in science education research and reports worldwide. It has also triggered a sense of unease with the researcher regarding the condition of science education in the Foundation Phase in South African schools.

As a consequence, the aim of this study is to establish the current situation regarding Natural Science education in the South African national curriculum, specifically at the Foundation Phase level. Some recommendations on how to improve the aforementioned situation to the benefit of specifically Foundation Phase learners, but also of the South African population at large, will follow from the investigation.

1.2 PROBLEM ANALYSIS

1.2.1 Awareness of the problem

Various indicators made the researcher aware of the problem regarding science education and the level of scientific literacy among the South African population.

1.2.1.1 Recent surveys and reports

In the first place, many assessment exercises and surveys were recently undertaken - both internationally and in South Africa - to test learner achievement and general public understanding of mathematics and science. The following areas are considered to be pertinent:

(a) Level of scientific literacy among South African learners

Various reports and surveys indicate that *scientific literacy* is at an extremely low level throughout the South African population, and in particular among learners.

- In a worldwide study on science achievement, the *Third International Mathematics and Science Study* of 1995, and the *Third International Mathematics and Science Study Repeat* of 1998 (hereafter TIMSS 1995; TIMSS-R 1998), South Africa performed worst among 38 participating countries. The Grade 7/8 and Grade 12 learners representing South Africa, were considered scientifically illiterate; especially female learners from all population groups performed particularly poorly. Another important finding of the study was that the majority of South African pupils cannot communicate their scientific conclusions, have difficulty articulating their answers, and even experience trouble in comprehending several of the questions. While these problems may to a certain extent be related to language of instruction, most pupils had not acquired even basic knowledge about mathematics and science (Howie 1999; Human Science Research Council (a):online; Rademeyer in *Beeld* 15/12/2004).

- The results of the 2003 *Trends in Mathematics and Science Study* (TIMSS 2003) were recently released by the Human Science Research Council (HSRC). These show that South Africa still lags behind other countries in the study of mathematics and science (HSRC (b):online).

- Extensive research was recently conducted by the Centre for Development and Enterprise (CDE) that produced the report, *From Laggard to World Class:*

Reforming Maths and Science Education in South Africa. This report found that a national crisis exists in higher-grade maths and science in South African schools (CDE:online; Muwanga-Zake 2003; Rademeyer in *Beeld* 15/12/2004).

- The *Grade 6 National Systemic Evaluation*, a survey commissioned by the National Department of Education and carried out by the Human Sciences Resource Council in late 2004, found that a vast majority of South Africa's Grade 6 learners are failing to achieve the expected outcomes in Natural Sciences, Language and Mathematics. This survey involved 34 000 Grade 6 learners from a representative sample of 1 000 mainstream schools around the country, and focused on their performance in Numeracy, Literacy and Natural Science. This survey provides an accurate reflection of the condition of schooling in the Intermediate Phase. The report found that more than half of the learners were not succeeding in Natural Science: an average score of 41% was achieved (News24.com; Pandor 2006). With regard to the three Learning Outcomes for Natural Science, learners achieved the lowest score for LO1 (35%) (Kanjee:online). This Learning Outcome, which focuses on scientific investigation, is the only learning outcome set aside for the Foundation Phase. With regard to their achievement in the four content areas, the average for Energy and Change was the highest (51%), with Life and Living in the second place (48%), Matter and Materials third (46%) and, substantially lower than the other areas, Earth and Beyond (31%) (Kanjee:online).

(b) Preparation of future scientists (successful school preparation and further study)

Mathematics, science and technology have come to dominate expectations regarding what counts as successful school preparation and further study. These subjects are regarded as essential in any modern society. Any country therefore needs to consider the question of how to prepare its youth to be effective citizens in a scientific, mathematical and technological world. It is through school education that the youth should be prepared in scientific and technological fields to cope with, and to contribute to the well-being of their country. Schultze and Nukeri (2002:154-55) found that a decreasing number of learners study science at schools and universities, which may be due to the negative public perception(s) of Chemistry and Science Technology. "If more learners can be motivated to pursue the study of science so that they understand the importance and relevance of science in their lives, learners can be prepared to be effective citizens in the scientific and technological South Africa desired by all" (Schultze and Nukeri 2002:154,172).

(c) Economic development and market demand

Currently, an increasing awareness is emerging that teaching and learning good school science may substantially contribute to economic growth and development. The importance of scientifically literate citizens and workers is likely to increase further in the coming decades as the result of the fast replacement of traditional technologies by new, efficient, science-based technologies (Ware 1999). A former Deputy Minister of Education, Mr Mosibudi Mangena, made the pertinent observation that in order for the country to provide employment for all, either through job creation initiatives or employment in the formal labour market, there needs to be a level of scientific and technological literacy high enough to sustain the expansion of the economy. Currently, however, South Africa does not have the capacity to allow the economy to expand without importing foreign scientific and technological expertise (Mangena 2002).

(d) Level of scientific literacy among South African adult population

Recent research stresses the importance of scientific literacy among adults in democratic societies. Blankley and Arnold (2001:65) find that citizens of a democratically driven country should be scientifically knowledgeable about science matters in order to make informed judgements about major issues in science, health and technology. They define civic scientific literacy as that level of understanding of scientific terms and constructs which enables people to comprehend the daily and weekly press, and to understand the essence of competing arguments on a given dispute or controversy. A survey conducted by the Human Sciences Research Council (HSRC 1999) found that most South Africans lack the background to take an informed interest in science matters and assimilate the valuable information. The HSRC survey also shows that men had passed more science and mathematics courses at all levels than women (Blankley and Arnold 2001:66). Public understanding of science interventions for South African adults needs to take into consideration the general lack of scientific vocabulary or scientific constructs that form the basis for the assimilation of scientific knowledge. If efforts to increase scientific literacy are to be successful, interventions would have to begin by taking steps towards laying the necessary foundation (Blankley and Arnold 2001:69).

While the above-mentioned areas do not refer to Foundation Phase learners specifically, they were provided to show that scientific literacy is currently at an unacceptably low level throughout the South African population. Therefore, an urgent need exists to lay a *solid foundation* for acquiring scientific knowledge and appropriate scientific skills in young learners, in order to promote scientific literacy.

1.2.1.2 Research on science for young learners

A significant number of studies have in the recent past been published on the topic of science education for young learners at Foundation Phase level. As even a cursory survey of the literature indicates, educationalists are adamant that science teaching should start at an early age, and should be given careful consideration and sufficient emphasis. Not only is *scientific literacy* on this level essential for coping with science and mathematics on higher levels, but it also equips young children to cope with daily life. The conclusion may justifiably be drawn that properly structured science teaching is essential for the total development of young learners. Worldwide, however, Natural Science education is rarely granted the same priority as reading, writing or mathematics, not uncommonly the last item on the daily programme, or even omitted altogether (Bentley, Ebert and Ebert 2000:40). Many countries also seem to devaluate the importance of the teaching of science by the time requirements stipulated in the policy documents (as opposed to the time and weighting attached to the teaching of language and mathematics). It is therefore important to establish the value that the Revised National Curriculum Statement (RNCS) attaches to Natural Science teaching in South Africa.

1.2.1.3 Perceptions among teachers in training

Significant with regard to the poor state of scientific literacy among South Africans, are the negative perceptions and attitudes of teachers and students in education towards science in general, and science teaching in particular.

In her capacity as lecturer (the third level module *Learning Area Natural Science* for students in B Ed (Early Childhood Development/Foundation Phase), University of Pretoria), the researcher conducted an informal survey of the perceptions of pre-service teachers towards the field of Natural Science teaching. Several significant issues emerged relating to students' understandings of and feelings towards Natural Science teaching. These issues also surfaced during students' presentations of science activities in class.

- Most commonly, students have negative attitudes towards Natural Science teaching. Many students believe that science is difficult, and consequently experience a fear of teaching science.
- Often, their dislike and fear of science and science teaching can be directly related to their own experiences during Primary and Secondary school. Negative perceptions of science during their own years at schools caused a "mental block" against the subject field lasting into their tertiary education.

- Many students agree that they lack basic science background knowledge themselves, and do not feel confident with the content, especially in the fields of Earth and Space science, Matter and Materials and Energy and Change. They tend to focus on topics and content from the Biological sciences.
- Some also lack the ability to select age appropriate, useful content for Foundation Phase learners, and to plan concrete, hands-on activities for this phase. Consequently, they tend to rely on textbooks and to act as “tellers of science”.

A few examples of student responses reflect the widely-felt negative attitude towards the field:

> *I hate science. I really didn’t enjoy it at all at school.*
> *I feel scared, unconfident, confusing. I want to do it, but when I don’t do it right, I don’t want to carry on.*
> *I was never good at science in school so that makes me negative.*
> *I’m afraid to do science as I cannot understand it too well. I think I just have this mental block against it which I need to get over.*
> *Difficult, hard work, long hours, failure, miserable.*
> *I cringe when I think about science simply because it is something that I am ignorant of and thus feel incompetent in.*
> *I never understood it, and nobody ever took the time to really show me.*
> *Science never really interested me much, I don’t know if it was the content or just the teacher who made me dislike the subject.*
> *Very anti-science. Bad experience with science teacher - she was not encouraging.*
> *Baie moeilik, goed kophou, onderwysers wat wet. aanbied nie seker oor hul vakgebied.*
> *NEGATIEF, verstaan nie wat verduidelik word nie ... te abstrak.*
> *Moeilik, oninteressant, tyd mors, dit gaan altyd gepaard met wisk.*
> *Hoërskool: aaklig, gejaagd, te min tyd, deurmekaar, haatlik.*
> *Onverstaanbaar, moeite, leerwerk, moeilik, stres my uit.*

Typical terms used by students to express their feelings towards science provide further evidence for the general feeling among teachers in training. These include the following:

> *difficult, confusion, complicated, scary, nervous, anxiety, frightening, frustrating, unable to understand.*

1.2.2 Statement of the problem

It appears that the low levels of scientific literacy among South Africans may be due to a variety of factors. One of the factors that came to the fore is a vicious circle of negative attitudes towards science and science teaching, starting during the early school levels and perpetuated by teachers who return to the schools while still harbouring these attitudes themselves. Clearly, it is crucial for South African society at large that the vicious circle be broken. The researcher is convinced that this will only happen by uncovering the roots of the problem through scientific endeavour, which will open the way to implant an opposite attitude towards science in young children. Without positive attitudes towards science education, teachers will not teach science effectively, and a solid foundation during the early years will not be established.

It is the belief of the researcher that young children are natural scientists and that education should build on what is given as inherent potential. Worldwide, the importance of science education for young learners is emphasised and the overall aim of science education programmes is often expressed as the promotion of *scientific literacy*. This is also the case in the South African Natural Science Learning Area Statement. Less clear from the official documents, however, is how important science teaching in the Foundation Phase is regarded. Only LO1 of the Natural Science Learning Area is prescribed for the Foundation Phase. The single Learning Outcome and the limited time and weighting attached to the teaching and learning of Natural Science, might point to a lack of emphasis, which should be a cause of concern.

While scientific literacy is not *established*, but only *promoted* during the Foundation Phase, it is important to consider whether the RNCS provides for the laying of a solid foundation for *becoming* scientifically literate. The value and priority attached by the RNCS to Natural Science education for Foundation Phase learners should be scrutinised, but also the perceptions and understandings of Foundation Phase teachers regarding Natural Science education. If scientific literacy is to be promoted, the acquisition of scientific concepts and scientific skills should take place during the early years of learning and specifically in the Foundation Phase. A solid foundation for becoming scientifically literate can therefore only be established if science is taught effectively.

The research problem is therefore stated as follows:

> Does the current situation in South African schools provide a solid basis for Natural Science in the Foundation Phase on which learners can build throughout life?

The research problem may be rephrased into a hypothesis, serving as a preliminary statement or guess "posited to direct one's thinking toward the solution of the problem" (Leedy 1997:60, 265). It is important to note that the relationship between problem and hypothesis is not that of question and answer. Rather, hypotheses are "tentative propositions set forth as possible explanations for an occurrence or a provisional conjecture to assist in guiding the investigation of a problem" (Leedy 1997:61).

The research hypothesis is formulated as follows

> The current situation regarding Natural Science education in the Foundation Phase does not establish a solid basis on which learners can build.

This hypothesis is to be tested against the results of the empirical survey (see Chapter 5), to establish whether it is supported by the evidence or not. To break up this problem into more manageable and quantifiable subsections, 13 specific research problem statements, which flow from the main problem statement, is provided in Chapter 5. These specific problem statements will direct the empirical research (see par.5.2.2), and will be revisited in the final conclusions (see Chapter 6).

1.2.3 Aims and objectives

This study entails an in-depth investigation into the theoretical aspects related to Natural Science education at the Foundation Phase level. It focuses on the current situation regarding Natural Science education in South Africa, and aims at establishing whether schools provide a proper foundation for science education at the Foundation Phase level in order to promote *scientific literacy*. The study will make recommendations to the national and provincial government and relevant role players to the benefit of all the South African citizens.

The following objectives express the necessary steps towards reaching the aim as stated above. It attempts to:

1. offer an inclusive view and understanding of what Natural Science education means and entails at the Foundation Phase level;
2. investigate the views of influential learning theorists on learning and teaching and their impact on classroom practice;
3. explore the Natural Science Learning Area in the Foundation Phase in current policy documents; and
4. explore the personal experiences, perceptions and understandings of teachers in the Foundation Phase with regard to Natural Science learning and teaching.

1.3 RESEARCH DESIGN AND METHODOLOGY

1.3.1 Choice of research design

A research design is a way of ensuring that the study proceeds systematically. The research design describes how the researcher plans to execute the stated research problem. It aims at planning, structuring and executing the investigation in such a way that the findings are as valid and reliable as possible (Mouton 2001:175).

The research design is described by Fouché (in De Vos 1998:152) as the *plan, recipe or blueprint* for the investigation which provides the guideline according to which a selection can be made for the most appropriate data collection methods. This study has a double focus, which results in the chosen research design:

1.3.2 Literature review

The first part of the research is a survey of the literature on the topic of Natural Science education for young learners (Foundation Phase). This part represents the primary aim of the study. The objectives of the literature survey are (1) to collect an acceptable body of knowledge on the topic; and (2) to gain a deeper insight into the field of Natural Science education, specifically in relation to children in the Foundation Phase. The relevant source materials that are reviewed, include published books, research reports, articles from periodicals and journals, as well as official curriculum documents, departmental reports, acts, interviews with experts and Internet discussions. Results from the literature review are presented in Chapters 2, 3 and 4 of the study.

1.3.3 Empirical investigation

The second part of the study is undertaken within a quantitative paradigm. The quantitative part should be seen as supplementary to the literature review, as a means of establishing the perceptions of teachers in practice regarding the topic.

One of the most common quantitative research techniques is the *survey technique* which involves the collection of primary data by selecting a representative sample of the population under study through the use of a questionnaire (Hopkins:online). The questionnaire, containing rating-scale and closed (yes/no) items, was distributed among Foundation Phase teachers in practice.

The empirical research design as well as the results obtained through the quantitative research process, are presented, analysed and discussed in Chapter 5.

1.4 DEMARCATION OF THE FIELD OF STUDY

As indicated by its title, the study is primarily concerned with the value, place and method of teaching the Natural Science Learning Area in the Foundation Phase. The scope of the study is consequently restricted to educational issues (value, place, method) relating to the effective teaching of the Natural Science Learning Area in a particular age group (Foundation Phase).

The empirical part of the study did not attempt to be representative of the full complement of Foundation Phase teachers in South Africa. Instead, only a sample of schools from a delimited area falling under the Gauteng Department of Education was included.

1.5 DEFINITION OF TERMS

For the sake of general orientation, it is important that key concepts around which the study is built are properly defined. While many of the following terms will be revisited in greater detail in forthcoming chapters, it seems appropriate to briefly circumscribe their meanings at the start of the study.

1.5.1 Science

The McGraw-Hill Concise Encyclopaedia of Science and Technology (2nd ed, p. 1647), as quoted by the Department of Education (2002 (b):5), describes “science” as follows:

> What is today known as “science” has roots in African, Arabic, Asian, American and European cultures. It has been shaped by the search to understand the natural world through observation, codifying and testing ideas, and has evolved to become part of the cultural heritage of all nations. It is usually characterised by the possibility of making precise statements which are susceptible to some sort of “proof”.

For an endeavour to be considered “scientific”, only particular methods of inquiry are generally accepted. These promote reproducibility, attempts at objectivity, and a systematic approach to scientific inquiry. The acceptable methods include formulating hypotheses, and designing and carrying out experiments to test the hypotheses. Repeated investigations are undertaken, and the resulting methods and results are carefully examined and debated before they may claim validity. Knowledge production in science is an ongoing, usually gradual process, but occasionally knowledge leaps forward as a new theory replaces the dominant view (the so-called paradigm shift). As with all other knowledge, scientific knowledge changes over time as people acquire new information and change their ways of viewing the world (*cf.* DoE/GIED 2002:105).

The very essence of the broad term “science” is hard to pinpoint, among other reasons because the subject field is so vast and can be perceived in numerous different ways. Science should rather be regarded as having various facets: while none of them in itself provides sufficient description of its nature, taken together they present a rich and complex view of science (Fleer and Hardy 1996:15). This will be discussed in detail in Chapter 2 (see par. 2.2).

1.5.2 Natural Science

The *Natural Sciences* may be defined as the scientific endeavours dealing with the objects, phenomena, and laws of nature and the physical world (High/Scope:online; see par. 2.2.2).

1.5.3 Scientific literacy

As the Natural Science Learning Area aims at promoting *scientific literacy* (DoE (b) 2002:4), the concept requires clarification. Since this will be attempted in more detail in Chapter 2 (see par. 2.5.2), a brief definition, as formulated by the OECD/PISA (OECD 1999, in Goodrum, Hackling and Rennie 2001), suffices at this point:

> Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.

1.5.4 Outcomes-based Education (OBE) and Curriculum 2005 (C2005)

The teaching approach adopted in South Africa is that of outcomes-based education (OBE), with Curriculum 2005 being the curriculum approach developed for South Africa. OBE, constituting the foundation of the South African curriculum approach, can be described as follows: a learner-centred, results-oriented approach to learning based on the beliefs or assumptions that all learners must be granted the opportunity to reach their full potential; that the learning environment should create a culture of learning, and that all stakeholders involved must be cooperating partners (Van der Horst and McDonald 2003:5-6). OBE is not planned around specific prescribed subject matter which learners are required to learn, but rather around a set of Critical Outcomes (see par.1.5.10) and Learning Programmes. The latter contain eight Learning Areas, each with their own Learning Outcomes. In OBE, the *process* of learning is considered as important as the *content*. By spelling out the outcomes to be achieved at the end of the process, both the process and the content of education are emphasised. The outcomes are intended to encourage a learner-centred and activity-based approach to education (DoE (a) 2002:10-11).

1.5.5 The Revised National Curriculum Statement (RNCS)

The South African National Curriculum Statement, introduced in 1997, faced considerable challenges. It was consequently strengthened and streamlined in the Revised National Curriculum Statement (RNCS). The RNCS is not a new curriculum, but builds on the principles, purposes and thrust of Curriculum 2005, emphasising constitutional and democratic values, as well as education for justice and social citizenship with a view to a non-racial, non-sexist, and democratic South Africa. It also affirms the commitment to outcomes-based education. The RNCS was introduced in the Foundation Phase in 2004 (DoE/GIED 2002:2; DoE (a) 2002: 4-7).

1.5.6 Learning Programmes

The RNCS is implemented by means of Learning Programmes. These are described as structured and systematic arrangements of learning activities that include content and teaching methods promoting the attainment of Learning Outcomes (DoE (a) 2002:15; Van der Horst and McDonald 2003:49). Learning Programmes must ensure that all Learning Outcomes and Assessment Standards are pursued and that each Learning Area is given its prescribed time and emphasis (DoE (a) 2002:15).

In the Foundation Phase, three Learning Programmes are offered: Literacy, Numeracy and Life Skills (DoE 2003:19). These Learning Programmes should provide for the holistic development of learners by:

- providing a framework for interpreting Assessment Standards and developing activities required to achieve the Learning Outcomes;
- giving guidance on how to plan for knowledge acquisition, skills development and formation of values and attitudes;
- giving guidance on assessment, recording and reporting learner achievement against the Assessment Standards; and
- illustrating progression of learners in the phase (DoE 2003:27).

All three Learning Programmes have as their backbone the development of particular concepts and skills. These are described in the Learning Outcomes from the Languages, Mathematics and Life Orientation Areas respectively. At the Foundation

Phase level, all Learning Outcomes and Assessment Standards from the other Learning Areas must be addressed within the three Learning Programmes (DoE 2003:27-28).

1.5.7 Learning Areas

A Learning Area is a field of knowledge, skills and values which has unique features as well as connections with other fields of knowledge and Learning Areas (DoE (a) 2002:9-10). The National Curriculum Statement distinguishes between eight Learning Areas. These are:

Languages	Technology
Mathematics	Social Sciences
Life Orientation	Arts and Culture
Natural Sciences	Economic and Management Sciences

1.5.8 Learning Area Statements

Each Learning Area has its own Learning Area Statement, stipulating what is expected of learners in each grade. The statement identifies the goals, expectations and outcomes to be achieved through related Learning Outcomes and Assessment Standards, but does not indicate content or methodology (DoE 2002:2).

Learning Outcome statements indicate what the learner is required to do under specific conditions (Van der Horst and McDonald 2003:60). They have a twofold purpose (Van der Horst and McDonald 2003:59):

(1) it enables the teacher to know in advance what the learner is expected to know and do; and

(2) it enables the learner to know in advance what s/he is expected to know and do.

Within the Natural Science Learning Area, a particular relationship between the content areas and the Learning Outcomes is supported. The RNCS selects Learning Outcomes that would foster the learner's ability not only to acquire science knowledge, but also to apply it. This implies that the learner should be able to operate and work with knowledge, to recognise when an idea is relevant to a problem, and to combine relevant ideas. Progression is consequently not only measured in terms of the amount of knowledge a learner can recall, but rather by his/her ability to plan and carry out investigations involving knowledge, and to interpret and apply that knowledge both inside and outside of the classroom situation. The Learning Outcomes for Natural Science can be defined as the "operations which the learner must be able to do on a certain range of scientific knowledge" (DoE (b) 2002:6-7).

The RNCS Learning Outcomes and Assessment Standards build on the Critical and Developmental Outcomes inspired by the South African Constitution, and developed in a democratic process. They describe the kind of citizen the education and training system should aim to produce.

1.5.9 Outcomes

Van der Horst and McDonald (2003:248) define outcomes as the end product of the learning process. Outcomes clearly state what knowledge, skills and values a learner should be able to demonstrate and apply appropriately. The South African OBE system distinguishes between three different levels or types of outcomes, namely Critical, Developmental and Learning Outcomes.

1.5.10 Critical Outcomes

Van der Horst and McDonald (2003:247) define Critical Outcomes as broad, generic, cross-curricular outcomes that focus on the capacity to apply knowledge, skills and attitudes in an integrated way. The seven Critical Outcomes are rooted in the Constitution of South Africa and aim at developing "a prosperous, truly united, democratic and internationally competitive country with literate, creative citizens leading productive, self-fulfilled lives in a country free of violence and prejudice" (DoE, in Van der Horst and McDonald 2003:47).

For the sake of reference, the Critical Outcomes (CO) are listed below:

CO1: Learners should be able to identify and solve problems and make decisions using critical and creative thinking.
CO2: Learners should be able to work effectively with others as a member of a team, group, organisation and community.
CO3: Learners should be able to organise and manage themselves and their activities responsibly and effectively.
CO4: Learners should be able to collect, analyse, organise and critically evaluate information.
CO5: Learners should be able to communicate effectively using visual, symbolic, and/or language skills in various modes.
CO6: Learners should be able to use science and technology effectively and critically, showing responsibility towards the environments and the health of others.
CO7: Learners should be able to demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

The Developmental Outcomes, which contribute to the full personal development of each learner, envisage learners who are 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;
- explore education and career opportunities; and
- develop entrepreneurial skills (DoE (a) 2002:11).

1.5.11 Learning Outcomes (LO)

Learning Outcomes describe what learners should know, demonstrate and be able to do (i.e. knowledge, skills, values) at the end of a grade, phase or band. The Learning Outcomes are based on critical and developmental outcomes (Van der Horst and McDonald 2003:48). They do not prescribe content or method, but are intended to ensure integration and progression in the development of concepts, skills and values through the Assessment Standards (DoE (a) 2002:14).

1.5.12 Assessment Standards (AS)

Assessment Standards describe the level at which learners should demonstrate their achievement of the Learning Outcome/s and the way (depth and breadth) of demonstrating their achievement. They are grade specific and show how conceptual progression should occur in a Learning Area (DoE (a) 2002:14).

Whereas Learning Outcomes describe what learners should know and be able to do, Assessment Standards describe the minimum level, depth and breadth of what is to be learnt. It follows that Learning Outcomes in most cases remain the same from grade to grade, while Assessment Standards change as learners progress through different levels (DoE (a) 2002:14).

To conclude, the Learning Outcomes for the Natural Science Learning Area are the operations which the learner must be able to do on a certain range of scientific knowledge. The Assessment Standards define the levels at which the learners operate in an outcome, while the content areas or knowledge strands define the breadth over which the learners can operate at any particular level (DoE (b) 2002:7).

1.5.13 The Foundation Phase

The Foundation Phase (Grades R-3) resorts under the umbrella term of *Early Childhood Development*, which in its turn applies to the processes by which children from birth to at least nine years grow and thrive physically, mentally, emotionally, spiritually, morally and socially (Education White Paper 5 on Education Childhood Development: DoE 2001:3).The Foundation Phase is the first phase of the General Education and Training Band. The focus of this phase is on primary skills, knowledge and values, and the laying of a proper foundation for further learning (DoE 2003:19).

1.5.14 Foundation Phase teachers

For the purpose of this study, the Foundation Phase teacher is someone who is involved in the education of learners in Grade R, Grade 1, Grade 2 and Grade 3, and who fulfills the requirements as envisaged by the RNCS. In the RNCS, teachers are viewed as key contributors to the transformation of education and have a particularly important role to play. The RNCS envisages teachers who are qualified, competent, dedicated and caring, and who are able to fulfill roles such as mediators of learning, interpreters and designers of Learning Programme and materials, leaders, community members, citizens and pastors, assessors and learning area/phase specialists (DoE (a) 2002:9).

1.5.15 The Foundation Phase learner

In terms of the Notice 2432 of 1998 and the National Education Policy Act (Act No 27 of 1996), Foundation Phase learners range between 5 and 10 years of age. Learners may be admitted to Grade R in the year they turn six, but Grade R is not compulsory (DoE 2003:19). Foundation Phase learners include learners who experience barriers to learning. They enter school from various cultural backgrounds and contexts.

Foundation Phase learners may be included in the broad aims of the RNCS, which are developing the full potential of each learner, and creating life-long learners who, by the end of Grade 9, will be

- literate, numerate and multi-skilled;
- confident and independent; and
- compassionate, with respect for the environment and an ability to participate in society as a critical and active citizen (DoE (a) 2002:8).

1.5.16 The Natural Science Learning Area

The Natural Science Learning Area Statement envisages a teaching and learning milieu that recognises the variety of learning styles, and the culturally influenced perspectives of the people of South Africa. It starts from the premise that all the learners should have access to a meaningful science education which is learner-centred. Learners should be guided to understand not only scientific knowledge and how it is produced, but also environmental and global issues. The Natural Science Learning Area aims at providing a foundation on which learners can build throughout life, and deals expressly with the promotion of scientific literacy (Van der Horst and McDonald 2003:54).

Chapter 4 offers a detailed discussion of the Natural Science Learning Area.

1.5.17 Learning programmes

A learning programme is defined by the DoE (2003:2) as a phase-long plan that provides a framework for planning, organising and managing classroom practice for each phase. learning programmes will be translated into yearlong, grade specific *work schedules* and shorter activity-long *lesson plans* (DoE (a) 2002:15; 2003:2). These learning programmes should not be confused with the three *Learning Programmes* of the Foundation Phase (Literacy, Numeracy and Life Skills; see par. 1.5.6).

The development of detailed learning programmes is the responsibility of schools and teachers. Policy guidelines have been developed at national level (with provincial participation) for the development and implementation of effective teaching, learning and assessment practices, and materials were supplied by the Department of Education in the form of the *Teacher's Guide for the Development of Learning Programmes*. This guide is intended to support teachers in developing and implementing their own learning programmes within the policy framework provided in the RNCS (DoE 2003:1).

1.6 PROGRAMME OF THE STUDY (CHAPTER LAYOUT)

The layout of the present study is as follows:

Chapter 1: Orientation

The purpose of Chapter 1 is to orientate the reader and to introduce the research aim and objectives driven by the problem.

Chapter 2: Science education: its meaning and purpose

Chapter 2 offers an inclusive view of the scope of science in general, and of Natural Science education in the Foundation Phase in particular. The important notion of scientific literacy is explored, as well as the interrelated components of science, namely scientific knowledge (content), process skills, and the values and attitudes to be established at this level. Finally, a rationale for early childhood science teaching is proposed.

Chapter 3: Natural Science learning and teaching

Chapter 3 deals with issues relating to Natural Science learning and teaching. The views and influences of Piaget, Vygotsky, Gagné, Bruner, Ausubel and Gardner and their impact on contemporary classroom practice are reviewed. An exposition of a variety of methods, suitable for Natural Science in the Foundation Phase is also presented.

Chapter 4: The Natural Science Learning Area in the South African context

Chapter 4 focuses extensively on the Natural Science Learning Area in the Revised National Curriculum Statement. The concepts curriculum and integrated curriculum are clarified, and curriculum developments internationally and in Africa are explored. The chapter also considers the role of the teacher as the key to curriculum implementation, focusing on the challenges facing the teacher in this regard.

Chapter 5: Perceptions of Natural Science teaching: A survey

Chapter 5 deals with the current situation regarding Natural Science education in the South African Foundation Phase, by means of an empirical survey among a selected population. The research design is explained and the results of the quantitative survey presented and discussed.

Chapter 6: Conclusion and Recommendations

The final chapter wraps up the study by presenting some conclusions and recommendations resulting from both the literary and the quantitative survey. The research findings are intended to make a contribution to the improvement of the current situation regarding science education at the Foundation Phase level.

CHAPTER 2

SCIENCE EDUCATION: ITS MEANING AND PURPOSE

2.1 INTRODUCTION

The purpose of the present chapter is to clarify various issues concerning the notion of science and its teaching to young learners. It falls into two distinct parts. In the first part, an inclusive view is offered of what science, and in particular, Natural Science means and entails. The issues of the philosophy of science underlying current scientific endeavours, the relation of science to technology, and the various dimensions of science are briefly discussed.

In the second part, attention moves to Natural Science within the context of early childhood education. The important notion of scientific literacy is explored, as well as the interrelated topics of science knowledge or content, and the appropriate process skills, values and attitudes that must be established at this level in order to promote scientific literacy. Finally, a rationale for early childhood science education is proposed.

2.2 WHAT IS SCIENCE?

In order to establish the basis from which the study proceeds, it is important at the outset to offer an overview of meanings connoted by the word “science”. The notion has both a multiplicity of meanings, and a common set of concepts and processes underlying the diversity of its aspects, dimensions, and uses. In order to properly grasp the potential of science on the one hand, but also its risks and limitations on the other, an understanding of these basic concepts is essential (High/Scope:online). A clear understanding of the nature of science is also important for formulating a convincing rationale for the inclusion of science education in the curriculum for young learners. (Fleer and Hardy 1996:13). In what follows, different views or definitions of science, in particular of the Natural Sciences, are briefly presented.

The word “science” originates from the Latin noun “scientia”, which again relates to the verb “scire,” meaning “to know”. Science, in other words, refers to “knowledge”, but in its modern usage, knowledge of a particular kind (Encarta Encyclopedia 2004).

A broad but handy definition of science distinguishes between the following four aspects (Encarta Encyclopedia 2004):

- The observation, identification, description, experimental investigation, and theoretical explanation of phenomena
- Methodological activity, discipline or study
- An activity regarded as requiring study and method
- Knowledge gained through experience.

2.2.1 The fields of science

Within the broad category of science, various fields are distinguished, for example, the human and social sciences, economic and management sciences, etc. The very essence of science is extremely difficult to pinpoint, among other reasons because the subject field is so vast and can be perceived in numerous different ways. Science means different things to different people. The *physicist* or *engineer*, for example, will view science as a set of tools (conceptual and mathematical) for thinking and for solving problems. The *naturalist* may regard science as consisting of the materials, events, and changes that have occurred during the history of the existence of the planet and universe, as well as the tools for discovering and understanding these events. The *historian* may see science as a record of ideas and discoveries, while the *nonscientist* will view science as a window on worlds of wonder. However, science and the technologies resulting from scientific endeavours are probably regarded by most people as essential to maintaining contemporary culture, and the products of science make life easier, healthier, safer and more productive for everyone (High/Scope: online).

Please note: In popular and everyday usage, the word *science* often refers specifically to the *Natural Sciences*. In accordance with this popular usage, this study will use the term *science* as an abbreviation to refer to the more narrow field of the *Natural Sciences*.

2.2.2 The structure of the Natural Sciences

The Natural Sciences are often described as the scientific endeavours dealing with the objects, phenomena, and laws of nature and the physical world. These, of course, cover an immense field of enquiry and application. In the table below, the classes, principle branches and sub-fields of the Natural Sciences are indicated. The classifications are necessarily arbitrary because of interlocking relationships, overlapping, and cooperation between the sciences (pure and applied) that do occur (e.g. biochemistry, bioengineering, etc.)(Encarta 97 Encyclopedia).

The various disciplines of the Natural Sciences can be presented schematically in the following way:

TABLE 1

Natural Science		
Two classes:	Physical science	Biological (Life) science
Principle branches:	physics, astronomy, chemistry, geology	botany, zoology
Subdivisions / fields:	mechanics, cosmology, physical chemistry, meteorology	physiology, embryology, anatomy, genetics, ecology
Applied science:	aeronautics, electronics, engineering, and metallurgy	agronomy and medicine

(Encarta 97 Encyclopedia).

2.2.3 The relationship between science and technology

Many researchers believe that the study of technology should be an important part of school science for young learners. A clear distinction between science and technology, however, is difficult to draw. It is therefore important to notice the close relationship, but also the distinct differences, between these two fields of knowledge.

Science and technology are interactive and share a mutually beneficial relationship. Understandings about the world generated through science often provide the basis for technological solutions to human problems. In turn, invented physical tools (instruments for measuring, observing, analysing) and data processing tools (calculators, computers) help scientists to make better observations, measurement and investigations (Bentley, Ebert and Ebert 2000:14; Carin and Bass 2001:27).

In the words of Bentley, Ebert and Ebert, "science seeks to understand the world around us, and technology takes scientifically generated knowledge and gives it *practical value* by developing processes and materials that extend capabilities" (2000:14). For the scientist, technology is a tool as well as the toolmaker. Scientists use a variety of tools in their work, many of which (e.g. calculators, computers) are now omnipresent in science and technology (Bentley, Ebert and Ebert 2000:14).

Some of the main differences between science and technology are schematically presented in the following table:

TABLE 2

	Science	**Technology**
At the core is:	enquiry	design
The goal is to:	understand the natural world	make modifications in the world to meet human needs
Theories are validated:	through observations of natural phenomena	by applying tools, materials and processes
The social purpose is to:	generate new knowledge	respond to human and social needs

(Carin and Bass 2001:27; Bentley, Ebert and Ebert 2000:14)

Bentley, Ebert and Ebert (2000:14) introduce the two concepts of *scientism* and *technologism*. The former refers to the notion that the only true knowledge is produced by science, while the latter notion holds that a technological solution exists to all our problems. These beliefs lead people to false expectations of science and technology, that is, that these disciplines have the power to find out everything there is to know, and to solve all problems.

Because the activities employed in science education emulate the practices of "real" scientists, it is important to understand the nature of science itself. In the following sections, two prominent philosophies or approaches to the scientific endeavour are briefly mentioned, after which various dimensions of science are listed and discussed.

2.3 TWO PHILOSOPHICAL APPROACHES TO SCIENCE

Science is not the monolithic cognitive whole it sometimes appears to be. The fields of science and the way it is conducted, are fundamentally dependent on a particular philosophy of science, even when this remains tacit. What and how people think about the nature of science, have changed over time. This resulted in changes in the ways in which people understand their surrounding world, as well as in new philosophies of science. Philosophical issues are not unimportant even to the teacher only occasionally involved with science. An understanding of philosophical issues will ultimately provide the teacher with a stronger foundation for the teaching of science and is therefore included in this study.

In order to understand the contemporary views of science, it is convenient to investigate the differences between two approaches to science which dominated its recent history. As one superceded the other, a comparison simultaneously provides a simplified glimpse of the evolution of the philosophy of science over the past century.

The approach of modern scientists to their field of study differs significantly from what prevailed a few generations ago. The "big picture" has changed, or, put in other words, a scientific revolution or *paradigm shift* has occurred. It is customary to label the earlier view with the term *positivism*. The *positivistic* approach to science is now generally discredited and superceded with the approach called *constructivism* (Bentley, Ebert and Ebert 2000:15). A brief overview of the two approaches is provided in the following sections.

2.3.1 Positivism

The roots of positivism can be traced back to "the father of modern science", Francis Bacon, but the term positivism was coined by the nineteenth century philosopher, Auguste Comte. This conception of science bloomed in nineteenth century Europe. As a philosophical system, "positivism denies the validity of metaphysical speculations and maintains that the data of sense experience are the only object and the supreme criterion of human knowledge" (Catholic Encyclopaedia:online). Positivism entails the idea that scientific knowledge can be objective and value free, and that scientific enquiry can produce certain knowledge which accumulates as experiments prove or disprove theories (Bentley, Ebert and Ebert 2000:16,17,22). The following five basic assumptions underlie and characterise the philosophy of positivism:

- A single, tangible reality exist “out there” which can be divided into parts, and which can be studied independently (the whole is just the sum of the parts).
- The observer can be separated from the observed (or the knower from the known).
- Observations are independent of time and context, implying what is true at one time and place will remain true in any other time and place.
- Causality is linear; there are no effects without causes and no causes without effects.
- Objectivity is possible; methodology guarantees that the results of an enquiry can be free from the influence of any value system (Lincoln and Guba 1985, quoted in Bentley, Ebert and Ebert 2000:16).

Many science textbooks and classroom practices still reflect and maintain positivist views, for example, when learners hear that scientists have “proven” something or when science is described as nothing more than a collection of facts (Bentley, Ebert and Ebert 2000:16). However, most philosophers today no longer consider the positivist assumptions to be logically defensible and these assumptions are now being replaced by a constructivist perspective.

2.3.2 Constructivism

The constructivist perspective can have a profound influence on a teacher’s approach to teaching science; it is therefore important that teachers understand what this philosophy entails. A brief overview follows.

Immanuel Kant, Henry James, Charles Sanders Peirce, and John Dewy were early thinkers who sowed the seeds for *constructivism*. A constructivist perspective on science states that, “instead of seeking proof, scientists work to convince their peers that what they propose reasonably fits the available data, aids understanding, and is useful in making predictions and decisions” (Bentley, Ebert and Ebert 2000:17). Although scientists may be able to show that their models and explanations work, they cannot prove a one-to-one correspondence to reality in the external world. Constructivists view science as a network of meanings negotiated in a community of practising scientists.

Assumptions underlying constructivism include the following:

- basic faith in the susceptibility of the physical universe to human ordering and understanding;
- science needs curiosity as driving force;
- science is dynamic and ongoing;
- science aims at comprehensiveness, simplification and openness;
- many value-oriented methods are utilised through science; and
- tentativeness and uncertainty are characteristics of constructivist views (Bentley, Ebert and Ebert 2000:17).

The philosophy of constructivism proceeds from the premise that:

- knowledge does not exist outside the bodies of cognising beings (that is, outside the mind of a learner);
- knowledge is the construction of reality; and
- individuals actively construct knowledge by connecting prior and newer learning while working to solve problems (Martin, Sexton, Wagner, Gerlovich 1994:45).

2.3.3 Constructivism and classroom practice

Although teachers do not necessarily follow a deliberate constructivist approach to teaching science in their classrooms, a number of implications for teaching practice can be derived from it:

- A constructivist approach recognises the value of a child's inherent curiosity.
- Science is viewed as a dynamic, continual process of increasing a person's understanding of the natural world.
- Knowledge construction occurs within each individual through interaction with other people and the environment.
- The teacher following a constructivist approach largely functions as a facilitator of knowledge construction and takes the following alternative roles: presenter, observer, question asker and problem poser, environment organiser, public relations coordinator, documenter of learning and theory builder (Bentley, Ebert and Ebert 2000:20; Martin *et al.* 1994:46,47).

In the constructivist approach, knowledge is regarded as an individual construction of reality through interaction with other people and the environment. A typical classroom setting consists of learners from various environments and, by implication, different "realities". Cultural aspects thus become an important factor in constructing scientific knowledge.

2.4 DIMENSIONS OF SCIENCE

Science is a dynamic field with many dimensions. Teachers need to understand the nature of science in order to teach learners about its nature as well as to develop effective learning environments in science. In the attempt to offer an inclusive view of what science means and entails, the various aspects of science should be accounted for. None of these can lay claim to providing the full picture; they should be viewed together for a comprehensive, rich and complex picture to emerge (Fleer and Hardy 2001:14,30). Fleer and Hardy's exposition of the nature of science serves as basis for the following discussion; their views are reflected upon, added to and questioned by providing those of other authors as well.

2.4.1 A body of knowledge

The most common denotation of science is probably that of a "body of knowledge" or a "body of facts", associated with particular disciplines such as biology, physics, chemistry, geology, astronomy, psychology, computing technology, and so forth. This is indeed an important aspect of the notion of science as an accumulation of knowledge from centuries of endeavour, consisting of facts, concepts, theories, and general understanding of the universe (Fleer and Hardy 2001:14).

A common misconception regards scientific knowledge as being certain, universal and unchanging. This is not true. All scientific knowledge should more accurately be regarded as preliminary, and theory-based. As Johnston says, "new discoveries broaden our understanding of the universe, changing the way we think and the way we view the world". Science should therefore rather be regarded as a *body of theories*, with presently accepted theories alway being tentative in nature and bound to be superceded with new and better theories as our understanding grows (Johnston 1996:3).

Johnston's view is in agreement with that of Wenham (1995:1) when he holds that the facts, concepts and theories that make up scientific knowledge are not permanent or beyond dispute:

> "They are much more like a report on progress so far, which future investigators will modify and even, maybe, contradict. Any scientific theory is, to put it simply, the best explanation which scientists have produced up to the present. Theories are not final, and ...., they are provisional, and are used until something is observed which contradicts them or which they cannot explain. When that happens to an important or influential theory, something rather like a scientific revolution occurs: old theories are discarded and new ones are invented, tested, discussed, negotiated, refined and eventually accepted, or rejected, by the scientific community."

2.4.2 A process of investigation

The scientific *process of investigation* is another common angle from which to approach this human endeavour. This angle tends to underline the distinctive nature of science from other forms of enquiry about our universe. Scientific enquiry is usually characterised as a highly disciplined, objective and value-free process of observing, inferring, hypothesising, and experimenting in the natural and physical worlds.

It should immediately be stated that there is no single, comprehensive and all-encompassing scientific process. Many forms of scientific method are and should be allowed to exist side by side. Few scientists nowadays support the idea that only the simple, "classical" procedure of observation, hypothesis, design, experimentation and conclusion can lay claim to being truly scientific. Rather, scientific investigation is a complex and dynamic process of thinking, conceptualising, theorising, observing, experimenting and interpreting, tailored to the object and circumstances of investigation. Furthermore, it also involves rather "unscientific" elements such as hunches, guesswork and developing alternative models (Fleer and Hardy 2001:14).

Ollerenshaw and Ritchie (1997:3) define the nature of science as being an exploration of the cosmos to discover or explain what, why, when, where and how things happened, are happening or are likely to happen within it. In answering the question, "What do scientists do?", many aspects of the scientific process many be distinguished:

observing, checking, recording, thinking, reading, comparing their own ideas with those of other scientists, asking questions, testing hypotheses, carrying out investigations and collecting evidence. Scientific investigation demands from the individual a healthy respect for evidence; it is not on a par with good guesswork, but involves the imaginative cross-referencing of clues, the elimination of irrelevancies and the use of evidence to explain events. Discoveries are rarely accidental, but arise from investigations which are carefully structured.

Marek and Cavallo (1997:3-4) also stress the double aspects of science as both a body of knowledge and a process. The fact that science is usually thought of as disciplines - biology, chemistry, geology, meteorology and physics - causes the content aspect to come to mind first. But scientists, and science teaching, for that matter, are just as much concerned with "experiences with phenomena and organizing those experiences so they make sense to us." They go even as far as denying content on its own to present science, defining it as the "process of finding facts, laws, principles, and concepts (1997:4)."

2.4.3 A set of values

Often neglected, but underlying much of the stature and validity of the scientific endeavour, is the set or sets of values serving as guidelines and driving forces to the process. Particular values include honesty, suspension of judgement, curiosity, and openness to new evidence (Fleer and Hardy 2001:15).

Essential to the validity of the scientific process and content, is the fact that the rules and values driving the endeavour should be accepted by all. For example, the multitude of methods all rest on the accepted value that only valid evidence may be used to arrive at defensible conclusions. Being tentative, scientific knowledge should always remain open to scrutiny and subject to continual refinement in the light of new evidence. The quest to construct coherent, tested, public and useful scientific knowledge, consequently requires a definite set of values and skills: to be creative, open to new ideas, to be intellectually honest, capable of evaluating arguments with scepticism, and to conduct scientific work in ways which are ethical, fair and respectful of others (Australian Curriculum Framework 2003: online).

2.4.4 One way of knowing the world

People have many ways of knowing and understanding their worlds. These include, among others, societal, religious, and cultural knowledge. Scientific knowledge differs from other kinds of knowing by the particular rules and methods it requires (ASTA:online). While these have influenced other bodies of knowledge, such as history, economics, the arts and religion, the claims of science have also brought it into tension with other areas of knowing, for example with religion (Fleer and Hardy 2001:16). People hold various personal views of the origin of the universe and of life. Religious explanations of the universe and life are, for example, based on faith and these explanations vary among different religions. While science may claim to be the dominant way in which humans make sense of and control the world, it has become an increasingly prevalent view that science should not be seen as the only means of knowing the world (Fleer and Hardy 1996:16).

The view that science should not be allowed to claim the only way of understanding, arises from the definite limitations to scientific knowledge, of which scientists are becoming increasingly aware. The following extract puts this perspective succinctly:

> Science can only deal with events or things that can be measured, observed or detected. It cannot be used to investigate all questions. There are beliefs that cannot be proved or disproved by their very nature (e.g. the meaning of life or the existence of supernatural powers and beings). In other cases a scientific approach that may be valid is likely to be rejected by people who hold certain beliefs (e.g. astrology, fortune-telling, and superstition). Scientists do not have the means to settle issues concerning good and evil. Answers to these questions must be found in religion, philosophy, cultural ideas and other systems of beliefs (ASTA:online).

2.4.5 A social institution

Science exerts powerful influences on society, and has profound effects on virtually all areas of life. Through science, people are able to develop a sense of place - they recognise that people from different backgrounds and cultures have different ways of experiencing and interpreting their environment, consequently a diversity of world views is associated with science and scientific knowledge (Curriculum Council:online).

Society wants its contributing members to be culturally literate so that they have enough background knowledge and ability to communicate, produce and improve the general welfare. When the culture of a society is primitive, knowledge is limited and fixed and its members can continue doing the same things in the same self-sufficient ways for many years to function as members of that society. In a modern, advanced society, however, knowledge must multiply quickly in order for citizens to be able to communicate efficiently with each other and to address matters of public policy. Scientific literacy is the part of cultural literacy that enables people to live intelligently in a society leaning heavily on science and technology. Scientific literacy should enable members of society to make sense of their daily exposure to major issues in regard to science, health and technology they may encounter via the media (Gega 1994:13).

2.4.6 A human endeavour

Science is part of human experience and has relevance for everyone - all people can experience the joy and excitement of knowing about and understanding the world in which they live. Knowledge of science enables people to value the systems and processes that support life on our planet, and to take a responsible role in using science and its applications in their daily lives (Curriculum Council:online). Victor and Kellough (2000:23) view science as “a continuing human endeavor to discover order in nature” and see the products of that endeavour as human knowledge - facts which are building blocks, reference points for the understanding of bigger ideas, the principles, generalisations, and concepts. These products are tentative and cumulative.

Scientists are people and are therefore prone to human error. Scientific knowledge, being a human product, is fallible and thus provisional. The scientific process can be executed poorly, just like any other human endeavour. Science may also be misused, particularly by those who apply the name of science to their efforts to “prove” their favourite cause, and without following the values and procedures appropriate to the task. Some scientists even produce fraudulent work. The data collected through human observation, experimentation and peer verification, must always be reviewed by the scientific community before it can be accepted as valid evidence. Scientific data of poor quality are usually exposed sooner or later through the work of other scientists.

The human dimension of science furthermore means that the process can never be completely free from personal values, opinions or bias. Some people make fewer mistakes, some observe better than others, but all are in the final instance subjective to a certain degree. Even strictly following the prescribed rules, and attempting to be strictly objective, do not exclude the presence and intrusion of bias: unconscious racial bias, gender bias, social status, source of funding or political leanings influence people's perceptions and interpretations (ASTA:online). Scientific knowledge should therefore not be regarded as privileged and unquestionable, but need to undergo the same type of scrutiny and peer review as would other forms of knowledge (Fleer and Hardy 1996:18).

2.4.7 Mediated by culture

It has become increasingly important to acknowledge the fact that science is never practised in a social vacuum. Any scientific endeavour always has a cultural dimension. The world is composed of different cultural groups. Cultural differences include those of race, religion, economic status, ethnic background, the home language of the child and in some instances, gender. Each group has developed their own ways of interpreting their environment. Different people have different ways of investigating their environment and ordering their understandings - this phenomenon is referred to by Bentley, Ebert and Ebert (2000:11) as "*traditional ecological knowledge*". It is important to acknowledge the fact that children from different cultural backgrounds interpret scientific terms and ideas from the perspective of their own culture. As science is intended to help children understand the world, it is crucial that teachers take the world of each child into consideration and not only the world of the dominant culture.

Science is for all learners. Meeting the needs of the diversity in classrooms, especially in a country like South Africa, is extremely challenging and is an important issue in education. Different backgrounds often offer rich heritages beneficial to all - it brings the perspectives of many cultures to a classroom and have a positive impact on the social climate of a classroom (see par. 4.6.4.2 on indigenous science knowledge). The goal of multicultural science education is that children understand the *consensus version* of science but they are not required to give up their traditional cultural beliefs (Martin *et al* 1994:258,294; Bentley, Ebert and Ebert 2000:12).

2.4.8 A part of everyday life

Many of our everyday experiences are full of science: we engage in a range of activities that require a great deal of scientific knowledge and skill. Yet we may never associate these activities with science.

Many adults do not regard themselves as scientifically literate, however we utilise the products of science and technology and act scientifically each day when we use the toaster, boil water, cook food or fertilise the garden. “Science” tends to be associated with school or laboratory experiences. Most people do not even recognise the extent to which they use and are influenced by the outcomes of science in their everyday lives. People use the products of scientific investigations and knowledge, and scientific approaches strongly influence the way they think about everyday situations (Fleer and Hardy 2001:21).

2.4.9 An inclusive definition of science

In conclusion, the following attempt at defining science complies with the above exposition of this multi-faceted phenomenon:

> Science is a dynamic, collaborative human activity that uses distinctive ways of valuing, thinking and working to understand natural phenomena. Science is based on people’s aspirations and motivations to follow their curiosity and wonder about the physical, biological and technical world. Scientific knowledge represents the constructions made by people endeavouring to explain their observations of the world around them. Scientific explanations are built in different ways as people pursue intuitive and imaginative ideas, respond in a rational way to hunches, guesses and chance events, challenge attitudes of the time, and generate solutions to problems. As a result of these endeavours, people can use their scientific understandings with confidence in their daily lives
>
> (Curriculum Council:online).

2.5 NATURAL SCIENCE FOR YOUNG LEARNERS

As seen in the previous sections, the scope of science is enormous and so is the scope of science for young learners. In what follows, attention turns towards science and the goals of science education at Foundation Phase level.

First to be considered, is the emergence of science in young learners. Second, the notion of scientific literacy, as that is the goal of all outcomes of science. Naturally, the foundation for scientific literacy is laid with primary science education, from which all further science learning proceeds. The next section deals with the constituents of primary science, namely the knowledge (content), the process skills, and the values and attitudes.

2.5.1 The emergence of science in young learners

In today's scientifically oriented world, the ability to think scientifically is crucial (Baxter and Kurtz 2001:18). The ability to think scientifically should therefore be promoted from an early age. But how do young children "think scientifically"? In other words, what is science for young learners? And what is the driving force for scientific development in young learners?

Many authors regard *curiosity* as the single most important prerequisite for scientific enquiry. For this there is no innate lack of potential in young children. Curiosity about their world is second nature to children - indeed, it is their nature. They are natural investigators and natural scientists in their eager searches for answers about the wonderful world around them (Hayton, in Atkinson and Fleer 1995:13). From the moment of birth, babies use their senses to investigate their surroundings. In fact, the activities or responses of the foetus in the womb may even be regarded as the earliest instances of scientific exploration. It is clear that scientific conceptual development, broadly defined, begins at an early age and is the result of experiences and exploration. Babies, for instance, quickly learn about the existence of gravity as they drop things out of their prams or high chairs. They become familiar with a fundamental law of nature: when things are dropped, they fall. Mealtimes, bath times, playing with toys, walks and outings, the birth of a new brother or sister, their personal hygiene, sickness - that is, all the normal explorations of childhood - provide countless opportunities for exploratory experience. The more such experiences they have, the better their scientific development is likely to be (Johnston 1996:5-7).

Children are constantly learning about the world around them, and the "scientific" concepts they form and encounter are those directly relevant to their world. That is of course what science is all about: investigating to discover, asking questions and identifying problems to solve, and finding answers about the immediate environment and the world. This creative process, the desire to search for answers, if properly encouraged and nurtured, will become a life-long habit. From their first encounter with a butterfly, to their observation of the stars, children are filled with a sense of wonder. The "why" questions of budding scientists begin with that natural wonder (Johnston 1996:5-7).

It is clear that science is inherently human and human attitudes provide the curiosity to activate its study, the perseverance to continue, and the qualities for making informed judgements (Martin *et al* 1994:23). It may therefore be claimed that the potential and the driving force for all scientific enquiry are inherently present in children from the earliest age.

The following paragraph presents a brief overview of what science for young learners entails.

When people think of science, the *content* of science comes to mind first. As seen previously, science is most often regarded as an encyclopaedia of discoveries and technological achievements - a body of information that can be memorised. Millions of discoveries, facts, and data have been compiled over thousands of years, and is still being gathered at an increasing rate. Not surprisingly, our age is often described in terms of the current "knowledge explosion". It has become impossible to know everything, and it is impossible to predict what content should be taught to learners that will be of use to them in their adult lives. However, as life should rather be viewed as *a series of problems*, the people who are best equipped to solve the problems they encounter, will be most successful in future decades. One may conclude that the skills to solve problems should be part of science teaching from the outset. For young learners, the emphasis should be on *doing* science, and not necessarily on *learning* the content of science only. Science for young learners should therefore rather be viewed as a verb than a noun: not science, but *sciencing*. *Action* at this age is as important as *facts;* the process, the way of thinking and acting, as important as a body of knowledge. Science for young learners may therefore be more appropriately defined in terms of the knowledge, skills, values and attitudes involved in the sciencing process (Lindt 2000:52,53; Van Staden 2002:8).

The scientific concepts, knowledge, skills and attitudes which young learners are developing, should be related to their everyday lives and the immediate world around them. Science for young learners should be concerned with real life, and not in the first instance with laboratories, test-tubes and Bunsen burners. In the words of Johnston (1996:5), "it is real science, relevant science, albeit in many cases unsophisticated, undeveloped or even not obviously science (tacit science)". Scientific concepts, knowledge, skills and attitudes should be developed equally and simultaneously. A solid knowledge foundation for future conceptual understanding is important, but it is equally important to develop useful life skills, in and out of school, and positive attitudes towards and within science. Without the required positive attitudes, the development of concepts and skills will be impaired, and without scientific skills, both future conceptual development and everyday life skills will be hampered (Johnston 1996:5).

2.5.2 Scientific literacy

"Scientific literacy" has become a key concept in thinking about science education for young learners. The promotion of scientific literacy as the *goal* of science teaching, has found its way in curricula worldwide (Harlen 2000:11; Bybee 1997 in Goodrum, Hackling and Rennie 2001). This is also the case in South Africa, where the whole purpose of the Natural Science Learning Area is described as the promotion of scientific literacy. It is consequently important to carefully consider the notion of scientific literacy, in particular what it entails at the Foundation Phase level, and how it can be fostered successfully in young learners.

2.5.2.1 The importance of scientific literacy

A rise in the importance of scientific literacy may be observed in curriculum developments worldwide, in particular England, Wales, the United States of America, and Australia. An Australian source formulates the reasons for this emphasis, and the accompanying rise in the awareness of science in society at large, as follows:

- to develop a scientifically literate society that deals flexibly with change and is capable of informed decision-making
- to encourage students to choose science as an attractive study career option, and
- to drive economic growth and advance social and environmental well-being (Prime Minister's Science, Engineering and Innovations Council (PMSEIC, 1999) in Goodrum, Hackling and Rennie 2001).

The above-mentioned reasons are evidently equally pertinent to the South African context. The ideal of a scientifically literate population in South Africa will suffer unless scientific literacy gets the attention it deserves, and is successfully promoted as an outcome of science education.

2.5.2.2 Defining scientific literacy

Before providing a definition of scientific literacy, Goodrum, Hackling and Rennie (2001) mention the following reasons why this concept should be carefully considered and defined:

- In the absence of a clear definition, no basis would exist upon which to determine whether progress towards scientific literacy has been achieved, or to assist learners towards progress.
- A definition should incorporate the fact that people are different and have different strengths and interests. Scientific literacy as a goal should reflect variations and differences in society.
- Scientific literacy as an outcome should provide guidance progressively as children move through school.

There are numerous views of scientific literacy. A few definitions of well-known organisations or authors are provided here. (Modern views of scientific literacy include mathematics, technology as well as the social and natural sciences).

The National Science Education Standards (National Research Council, 1996 as quoted by Carin and Bass 2001:12) provides such an inclusive view, when scientific literacy is defined as:

> "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity."

Another definition is that of the *Programme for International Student Assessment* of the Organisation of Economic Cooperation and Development (OECD/PISA 1999, as found in Goodrum, Hackling and Rennie 2001):

> "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity."

In similar terms, Goodrum, Hackling and Rennie (2001) define scientific literacy as

> "the capacity for persons to be interested in and understand the world around them, to engage in the discourse of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being."

While wording differs, the various views of the notion share some common features. Goodrum, Hackling and Rennie (2001) identify three main issues which feature prominently in discussions:

(1) the content and concepts of science
(2) the nature and processes of science
(3) the relationship between science and society.

Similarly, Millar (1988, in Bentley, Ebert and Ebert 2000:238) identifies competency in three areas as requirements for scientific literacy:

(1) understanding the scientific method;
(2) knowledge of the common vocabulary of science; and
(3) appreciation of the social impact of science.

In a study of existing curricula, Goodrum, Hackling and Rennie (2001) found that the focus is often on content to the virtual exclusion of the nature and processes of science. The relationship between science and society gets almost no attention at all. The result is an unbalanced curriculum and, according to these authors, "little chance that scientific literacy will be an outcome". The study shows how important it is to properly define the notion, and to clearly stipulate the educational goals involved.

2.5.2.3 The meaning and aim of scientific literacy

An informative summary of the meaning and aim of scientific literary is provided by the United States' *Benchmarks for Science Literacy* (AAAS 1993:xi) as found in Victor and Kellough (2000:18):

> "The aim is to provide literacy in science, mathematics, and technology in order to help people live interesting, responsible, and productive lives. In a culture increasingly pervaded by science, mathematics, and technology, science literacy requires understandings and habits of mind that enable citizens to grasp what those enterprises are up to, to make sense of how the natural and designed worlds work, to think critically and independently, to recognise and weigh alternative explanations of events and design tradeoffs, and to deal sensibly with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties."

The summary describes the scientifically literate person as someone who knows how to learn, to enquire, to gain knowledge, and to solve new problems. Throughout life he/she continues to enquire, and to increase his/her knowledge base. This person uses his/her acquired knowledge to self-reflect and to promote the development of people as rational human beings (Victor and Kellough 2000:18). Scientific literacy thus become a life-long habit and companion.

2.5.2.4 The promotion of scientific literacy in young learners

Scientific literacy in practice means that learners will be able to function confidently in relation to the scientific aspects of the surrounding world, and to see things in a "scientific way". It also implies an awareness of the nature and limitations of scientific knowledge, and the role of values in the generation of scientific knowledge (Harlen 2000:12,13).

According to Harlen (2000:13), the ultimate aim of promoting scientific literacy is to develop the "big", widely accepted ideas that enable people to understand and make sense of new situations they may encounter. These "big" ideas, however, are too abstract and too far removed from everyday experiences to serve as starting point for learning. Science for young learners should rather build a foundation of small ideas that enable learners to understand events in their immediate environment, at the same time linking different experiences and ideas to build bigger ideas. The overall aim, in relation to the development of skills and attitudes, is for learners to develop the ability and willingness to recognise and use evidence in making informed decisions. Once again, the starting point should be for learners to become familiar with ways of identifying, collecting and interpreting evidence in relation to answering questions.

It should be said, as a final observation, that scholars are not unanimous as to the importance of scientific literacy in school curricula. The concept of scientific literacy is difficult to grasp and even more difficult to assess. Some researchers hold the view that scientific literacy is too demanding for the purpose of school science. Some even feel that most people lead useful and happy lives without being scientifically literate (Bentley, Ebert and Ebert 2000:239). However, the researcher believes that the previous discussions on the aim of scientific literacy suffice for a case to be made for its inclusion as a science education outcome, even from an early stage.

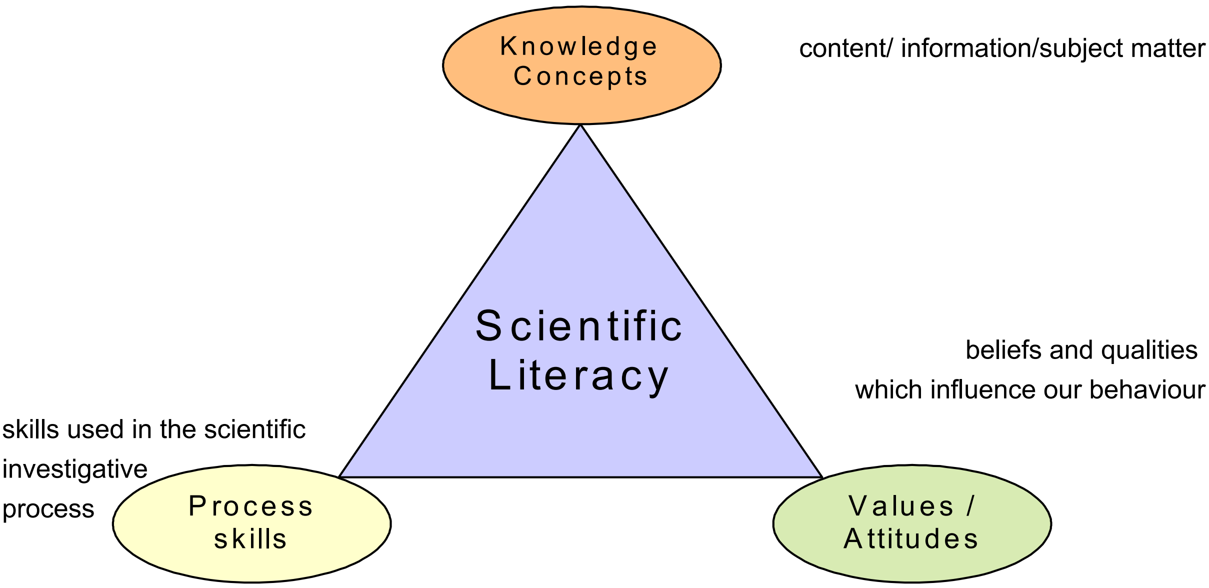
The attainment of scientific literacy depends on the acquisition of scientific knowledge, skills, values and attitudes. However, scientific literacy does not automatically result from learning science. It has to be an intentional goal (Harlen 2000:14; Bauer 1996).

2.5.3 The components of science for young learners: Science knowledge, skills, values and attitudes

While the overall aim of the science curriculum is to develop scientific literacy, this aim may be broken down into components so that an achievable curriculum and programme can be planned. In order to promote the aim of scientific literacy, three components are distinguished: scientific knowledge/concepts, scientific process skills, and scientific attitudes (Harlen 2000:14).

The components of science are interrelated and working together to promote scientific literacy of learners. The following diagram (DIAGRAM 1) shows the interrelatedness of the three components with scientific literacy.

DIAGRAM 1: THE COMPONENTS OF SCIENCE



These components, according to which appropriate science teaching can be organised, are discussed in the following sections.

2.5.3.1 COMPONENT 1: Science knowledge/concepts for young learners

The term *knowledge* refers to content or information or subject matter (GDE/UNISA (3)2003:66).

As seen previously, the scope of the Natural Sciences is enormous (see par. 2.2.2). Provisional science knowledge is embedded in general concepts associated with wide-ranging disciplines, for example, biology, physics, chemistry, geology, astronomy, and the like (Johnston 1996:3). In the light of this broad scope, one may ask whether we are not being over-optimistic in expecting young children to cope with science, as many adults even have difficulty grasping basic concepts. Osborne's positive answer to the question rests on children's ability to express ideas about the natural world from a very early age, and to come up with credible efforts to make sense of their experiences. The fact that children's ideas may rarely correspond to the scientist's world view is not important, since the opportunity to discuss and investigate natural phenomena is an essential foundation on which children start to construct a scientific understanding of the natural world (Atkinson and Fleer 1995:15).

While science knowledge should be viewed as provisional, the basic ideas and processes that need to be taught usually retain their validity over extended periods of time. Another important question arises: how do we match what there is to be learned with what children actually need and can do? The answer is simple: science and applied science as practised by adults, have to be presented in forms compatible to what we know about children's capabilities. Ideas and processes need to be simplified, known interests and needs of children should be considered, and their physical coordination and skills should be taken into account (Gega 1994:15,16).

Acquiring knowledge and concepts allow young learners to develop scientific understanding of their world. Science needs a foundation upon which new knowledge and experiences can build. The core knowledge and concepts identified in the National Curriculum lead to the selection of the content of science activities and experiences. These will provide a foundation for science knowledge to build on. Osborne feels that the limited exposure provided in the secondary school years is not sufficient to assimilate the wide range of concepts that modern science embraces. It therefore becomes extremely important to provide sufficient experiences in the primary school to assist conceptual development in science (Atkinson and Fleer 1995:15).

Curriculum content differs according to cultural-specific criteria, therefore one finds great variation between different countries in the content and concepts included in national curricula for a particular age group (Bentley, Ebert and Ebert 2000:24). In South Africa, the RNCS has made efforts to establish frameworks that would outline the categories of scientific enquiry and the general concepts that would be most suitable for a school curriculum. The core knowledge and concepts (content) of the Natural Science Learning Area for the South African Foundation Phase is presented in Chapter 4 (see par. 4.6.4.1). It should be kept in mind that the overall aim of the curriculum is the promotion of scientific literacy. With this aim in mind, it is important that primary science lays the *foundation* of understanding across a range of ideas from all the content areas (Life and Living; Energy and Change; Matter and Materials; Planet Earth and Beyond). This will provide the context and knowledge through which learners are guided to achieve the outcome of scientific investigation (LO1: see par. 4.6.2.1).

2.5.3.2 COMPONENT 2: Science process skills

Skills refer to the ability to use knowledge to develop expertise at a particular task, in other words, the application of knowledge in a practical task (GDE/UNISA (3)2003:66).

Scientific skills are essentially those skills developed during the scientific process - but they are skills used for life and living, and are employed in our everyday lives (Johnston 1996:3,4). Johnson provides the following everyday examples: We *observe* the world around us, and begin to *ask questions* about what we see; we group things together (*classify*) and identify similarities and differences; we *make plans*, *investigate*, *predict* and *hypothesise*; we *measure*, *record*, *interpret* and *communicate*. Before buying a car, for example, we test-drive cars, make notes on the main criteria and come to an informed decision based on interpretation and reflection. In other words, we gain knowledge through the use of scientific skills. The skills necessary to learn about the environment and to solve problems should be developed and refined in children. These skills are referred to as the *science process skills*.

Children discover the content of science by using the processes of scientific enquiry, for example, through scientific investigations, class discussions and other teaching strategies. Through teaching the processes of enquiry, children learn the thinking skills and processes necessary to learn science (Harlen 2000:31; Lindt 2000:53). The science process skills are acquired skills - learners are not born with them. These skills should therefore flow from scientific investigations and experiences during the Primary grades (National Science Education Standards in Lindt 2000:53). Young children need to develop the abilities necessary for more advanced scientific enquiry in later years.

Specific explanations of what the process skills entail, are provided in the following section.

Process skills are explained as:

- the skills allowing learners to process new information through concrete experiences;
- the tools enabling children to gather and think about data for themselves;
- the skills enabling an inquisitive mind to discover answers;
- the learner's cognitive activity of creating meaning and structure from new information and experiences (Martin *et al.* 1994:11; Gega 1994:102; Lindt 2000:53; Bentley, Ebert and Ebert 2000:143; DoE (b) 2002:13).

As described in the Natural Science Learning Area, the role of the process skills in *teaching* can be seen as being building blocks from which suitable science tasks are constructed. A framework of process skills enables teachers to design questions which promote the kind of thinking required by the defined learning outcomes (see framework for process skills in par. 4.6.3). From the *learning* point of view, the process skills are the necessary means by which learners engage with the world and gain intellectual control of it through the formation of concepts (DoE (b) 2002:13).

The literature on process skills offers numerous discussions, often displaying differences in the composition, definition, the number of, and the sequence of the process skills. Lindt (2000:53) divides process skills in three progressive levels, each skill building on and overlapping with those acquired earlier:

- Basic (observing, comparing, classifying, measuring, communicating);
- Intermediate (inferring, predicting); and
- Advanced skills (hypothesising, defining and controlling variables).

Lindt regards the basic skills as those appropriate to pre- and primary learners (corresponding to Foundation Phase learners). As learners move through primary grades and master these skills, they should become versed in performing intermediate process skills. A solid foundation of basic and intermediate process skills prepare them to apply those skills to the more sophisticated and abstract advanced (integrated) process skills.

More commonly, the process skills are divided into basic (observation, inference, classification, communication, measurement, and prediction) and integrated process skills (identifying and controlling variables, defining terms operationally, formulating hypotheses, collecting and recording data, interpreting data, drawing conclusions), based on *Science: A Process Approach (SAPA)* of the American Association for the Advancement of Science (1975) (Bentley, Ebert and Ebert 2000:133). De Jager and Ferreira (2003:188) describe the basic skills (corresponding to Lind's basic and intermediate process skills) as simpler skills appropriate for pre-primary up to Grade 5 learners and advocate the integrated skills as appropriate to the higher grades as learners in lower grades might still be too immature to cope with them. Integrated process skills are a higher-level application of the basic skills.

Teachers play a crucial role in the acquisition of science process skills. It is therefore important that teachers understand what each of the process skills involves, and know how to apply them in practice. However, it is a real cause for concern that many South African teachers may not be familiar with the concept of process skills development and therefore not pay attention to the promotion of these skills (De Jager and Ferreira 2003:188). Teachers may be unaware of what the process approach and associated development of these skills entail. De Jager and Ferreira refer in their study specifically to secondary school Biology teachers, but the assumption is probably equally valid for Foundation Phase teachers (Compare par. 5.10.2, results of the empirical survey: specific research question 9).

Following is a comprehensive list of science process skills, compiled from various sources, including the RNCS Learning Area Natural Science document (NSLA). Those process skills included in the NSLA (DoE (b) 2002:13-14) are marked with an asterisk*.

Although many sources present these skills in a specific sequence, there are strong arguments against rigid sequencing, mainly because process skills are dependent upon the specific investigative process. Consequently, the list provided Table 3 does not necessarily imply sequence of importance, nor does it imply an orderly sequence of steps (see par. 3.5.3: progression in process skills).

TABLE 3

PROCESS SKILLS	DESCRIPTION
* **OBSERVING & COMPARING**	*Observing* is the broadest and most fundamental of the scientific thinking process skills. Information about the world is gathered mainly through observation, by using the appropriate senses, and instruments that extend the senses (Gega 1994:71). Observation of the natural world is the first step taken in sciencing. It always proceeds from prior personal knowledge (Carin and Bass 2001: 42). Observing is more than simply seeing: it involves preliminary selection, classification, and even evaluation. While learners use their senses appropriately to gather information, they select what is important from what is unimportant (Western Cape Education Department 2003:11). A person has observed something in the scientific sense when they have both perceived it and realised something of its significance (Wenham 1995:6). Observing and comparing as described by the DoE (2002:13) may involve the learner in noting detail about objects, organisms and events with and without prompting by the teacher, noting similarities and differences, describing them in general terms, or describing them numerically. According to Lindt (2000:54), the teacher should reinforce observation skills by using strategies that require children to observe carefully to note specific phenomena that they might overlook. As their observation skills develop, children will naturally begin to compare, contrast and identify similarities and differences. Comparing is the first step toward classifying (Lindt 2000:54).
* **SORTING & CLASSIFYING**	*Classifying* starts when children group and sort real objects according to some common property; in other words, placing objects or events in groups or arranging them in order according to their properties (e.g. colour, shape or size) or their functions. To be able to *group*, children need to compare objects and develop subgroups or subsets that share common characteristics unique to that group (e.g. a jar full of buttons can be sorted into subgroups according to colours. They should also be able to provide reasons for the categories (Carin and Bass 2001:44; Gega 1994:90; Lindt 2003:54; WCED 2003:11).

* **MEASURING** **ESTIMATING**	*Measuring* is the skill of quantifying variables using a variety of instruments and standard or nonstandard units. Measuring can involve numbers, length/distance, area, volume, mass, weight and temperature. It involves placing objects in order such as sequence (seriation) or according to length or shade. Own inventions of units of measure help children realise the need for standardised units (e.g cm).Learners choose and use appropriate instruments such as rulers, tapes, scales, clocks and thermometers to make measurements. They could also use their experiences to take a good guess of the answer (estimating) (Carin and Bass 2001: 44,46; Lindt 2000:55; WCED 2003:11).

* **COMMUNICATING SCIENCE INFORMATION**	Children need to show, tell or share the information they have found from their observations or experiments with others in a way that is understood by and meaningful to all (Van Staden 2002:14). Scientists share their findings with the rest of the world through communication. In science for young learners, communicating refers to the skill of describing phenomena - they report on their investigation. This can be done by means of mathematical language, dramatic or artistic skills (words or gestures), making charts or graphs, recording data, constructing exhibits and models or drawing diagrams, drawing pictures and maps (WCED 2003:11; Lindt 2000:55; Gega 1994: 90,91). *Communicating science information* may involve learners in communicating through oral reports, writing prose texts, using an art form such as poetry, drama or comic strip, and using graphic forms, such as posters, diagrams or pie-charts. More conventional ways of communicating science, such as tables, concept maps, word-webs, graphs, physical constructed models or enacted models, for example, using people to show the motion of the planets around the sun, are also involved (DoE (b) 2002:14).

* **RAISING QUESTIONS ABOUT A SITUATION**	*"Raising questions* about a situation involves thinking of questions which could be asked about a situation, recognising a question which can be answered by scientific investigation (as opposed to a question which science cannot answer), or rewording the question to make it scientifically testable" (reprinted from DoE (b) 2002:14). After discussing a situation, learners can come up with their own questions for further investigation. It is through questioning that children can forge links between experiences and make sense of the world. Teachers, and eventually children themselves, should learn to recognise the distinction between investigable questions and types that cannot be answered by scientific activity (WCED 2003:11; Harlen 2000:35). Learners should be encouraged to always think about reliability and validity of findings. The teacher can act as model for learners to follow and ask probing questions (WCED 2003:11).
INFERRING	An inference is an interpretation of, explanation for, or tentative conclusion about what is being observed. It is based on prior knowledge and experience (Carin and Bass 2001: 44,47). Inferring means that children make a series of observations, categorise them, and then try to attach meaning to them (Lindt 2000:55).
* **PREDICTING**	Predicting and inferring is closely related, but they also have some critical differences. A prediction is a statement about a future event or a possible outcome, based on prior knowledge, collected data, or some hypothesis. A prediction compares a current piece of data with trends observed in the past. It is more than a simple guess which cannot be justified in terms of a hypothesis or evidence. While young children would not realise the difference between a hypothesis and a guess, they do make use of evidence or past experience to make predictions (foretell - what will happen if something is changed). This is more than guessing. For example, they foretell what will happen when water is heated. In order to foster development of the skill of predicting, teachers should help children to become aware of their reasoning and to use evidence more consciously (Harlen 2000:37; Carin and Bass 2001:49; WCED 2003:11; Frank 2001:40).

* **HYPOTHESISING**	Frank (2001:39,40) explains a hypothesis as an *if-then* statement of the *expected outcome* of an experiment (for example: *If* the amount of fertiliser in the soil is increased, *then* the amount of plant growth will increase). It is a generalisation based on what has been observed, rather than what one thinks should be observed and implies a cause-effect relationship - not a guess. As a process skill, hypothesising may involve the learner in naming possible factors which could have an effect on a situation, giving reasons why something has happened, stating a reason or cause for something, or using prior knowledge as well as information given in the task. Learners therefore generate a possible solution to a problem that can be tested through an investigation (DoE (b) 2002:14; WCED 2003:11).
* **RECORDING INFORMATION**	Learners use different ways to present their data and to record information, e.g., tables, graphs, posters. It may involve the learner in recording in a prescribed form (sentences, lists, tables, labelled diagram), selecting a suitable form in which to record the information when asked to do so, knowing when it is important to record, and doing so without being prompted by the teacher (DoE (b) 2002:13; WCED 2003:11).
* **INTERPRETING INFORMATION**	Learners need to develop the ability to link concepts and knowledge which they have encountered in scientific investigations. Interpreting information may involve the learner in a variety of ways of creating meaning and structure. Among these, two are particularly important for the Natural Sciences - *knowing* how to get information from a book, and *learning* from a printed page. Skills include cross-referencing information in books, finding information from knowing how a book is structured, and organising information using summaries or concept maps. Other aspects of interpreting include changing the form of information to other forms in order to reveal its meaning, looking for patterns in recorded information, predicting, interpolating for missing data, making an inference from given information, perceiving and stating a relationship between two variables, and constructing a statement to describe a relationship between two variables (WCED 2003:11; DoE (b) 2002:14).

EXPERIMENTING	To young children, *experimenting*, in simple terms, means "doing something to see what happens". Experimenting is different from the other process skills - in experimenting, objects or events are *changed* to learn what the results will be, while they are usually left unchanged when the other processes are used (Gega 1994:83). Children experiment when they state a hypothesis (to form ideas they want to test) and when they design a procedure to control variables (to change or vary only the condition that makes a difference in the experiment, controlling the other conditions so that they remain constant) (Gega 1994: 85,91). According to Van Staden (2002:13), young children are able to take part in simple experiments flowing naturally from a project or a theme.
* **PLANNING SCIENCE INVESTIGATIONS**	Learners need opportunities to create plans, design tests and surveys that will meet the needs of the investigation (WCED 2003:11). Planning science investigations is a composite of many of the skills and is in fact an Assessment Standard in its own right. The learner will be involved in rewording a vague question to make it into a testable prediction, deciding which variables matter in the problem or question, planning how to change one variable and keep the other variables constant (controlling variables), planning what variables to measure and how to measure them, knowing how to improve the accuracy and validity of the measurements, making inferences from results (their own results or someone else's results), and evaluating someone else's plan for a fair test (reprinted from DoE (b) 2002:14).

* **CONDUCTING INVESTIGATIONS**	*Conducting investigations* is also seen as an Assessment Standard, in which the learner sets up a situation in which the change in the dependent variable can be observed, while controlling interfering variables, measuring the variables, recording data, interpreting data to make findings, and reporting in qualitative and quantitative terms (reprinted from DoE (b) 2002:14). The planning of an investigation is closely related to carrying it out. It is often difficult to know where one ends and the other begins. The two often occur concurrently, particularly in the case of young learners. Developing the ability to conduct "fair test" investigations and other types of systematic enquiry requires time and experience. Young learners are only able to suggest in general terms what to do to find out something. At early stages, children can be expected to propose a simple investigation to answer a question or test a prediction; or say what they would do to make a test "fair" (Harlen 2000:39,40).

Learners at all grade levels should have the opportunity to use scientific enquiry and develop the ability to think and act in ways associated with enquiry. An overall view of the meaning and progression of these process skills should, however, also be kept in mind (Harlen 2000:17,18).

2.5.3.3 COMPONENT 3: Scientific values and attitudes

Values and attitudes are beliefs and qualities which influence our behaviour, for example, our consideration of other people and ourselves in all situations, and respect for other cultures, opinions and religions. *Values* are described as those "desirable qualities of character such as honesty, integrity, tolerance, diligence, responsibility, compassion, altruism, justice, respect, honour, etc." (GDE/UNISA (3)2003: 66,67).

Teaching the affective domain (feeling and valuing) in science education may seem unlikely: people tend to think of scientists as being detached and unemotional in their work. But feeling and valuing are the driving forces behind the whole scientific enterprise. It is important to develop children's attitudes and values as part of their participation in the classroom, because these influence the way they think about things and the degree to which they will engage in the consideration of various topics (Bentley, Ebert and Ebert 2000:51-52).

According to Johnston (1996:4), scientific attitudes in early childhood are equally important as concepts, knowledge and skills. Attitudes towards a subject or activity are as important as the subject itself. To develop informed attitudes towards science, it is necessary to have an idea of what science is. Without that, attitudes may be formed on the basis of the many myths about science and scientists that persist in popular belief. Young children are too inexperienced to form opinions and attitudes towards science themselves; if they seem to hold negative attitudes, these are the results of adult prejudices and of parroting views not their own. Arguments for fostering positive attitudes towards science are twofold: (1) the development of the whole child and (2) positive attitudes are likely to have an important effect on the development of scientific concepts, knowledge and skills.

In most national curricula, as is the case in South Africa, the development of scientific attitudes is not explicitly identified, but there is a widely acknowledged recognition of scientific attitudes in learning as an important outcome of science (Harlen 2000:18,19).

Two types of attitude related to science may be distinguished: attitudes *in* science and attitudes *to* science (Johnston 1996:93). As scientific attitudes form an integral part of what science for young children involves, the two attitudes demand more detailed consideration (Johnston 1996:46,93).

(a) Attitudes in science

Several attitudes may be considered to be particularly relevant to learning science: curiosity, respect for evidence, willingness to change ideas, critical reflection and sensitivity towards living things (Harlen 2000:20). These will be discussed (among others) under the following headings: (1) Motivating attitudes, (2) Group participating attitudes, (3) Investigating attitudes and (4) Reflective attitudes.

- *Motivating attitudes*

Curiosity is perhaps the most important attitude for exploration and can be possessed by anyone. All children show some curiosity, albeit in varying form. Some for instance continually ask questions, apparently never to satisfy their curiosity. They are naturally interested and have the need to know about everything they interact with. This leads to the ability to raise questions and to investigate. The need or drive to want to find out and to know, is a prerequisite for successful science learning. Children’s curiosity is at first immature: spontaneous, impulsive, easily stimulated by new things, but just as easily distracted. Children's curiosity should be encouraged and reinforced so that it may develop into a desire or a motivation to learn (Lindt 2000:57; Johnston 1996:94).

- *Group participating attitudes*

In scientific explorations, children are often required to work as part of a group. Group participation does not come naturally for children. In order to work effectively in a group, children need to acquire a number of skills and attitudes. They need to cooperate with each other, regardless of the group constitution (e.g. grouped according to friends, gender, ability, etc.). Cooperative children will be responsive to the needs of others, share resources, accommodate the ideas of others and settle difficulties within the group. Children also need to be tolerant in a group - to consider the needs and respect the ideas of others. Membership and roles (e.g. leadership, etc.) should change constantly to enable children to learn and display scientific attitudes in a variety of situations.

Responsibility is another important attitude. Children who take full responsibility for their learning are able to work independently and will try to overcome problems they face without adult help. They also need to learn that they are responsible for their own actions and that they cannot deny responsibility when something does not go according to plan. Children need to develop the idea that responsibility does not mean blame, and that they can be responsible for their scientific explorations without blame when things go wrong (Johnston 1996:96-98, Harlen 2000:19).

- *Investigating attitudes*

Creativity and inventiveness are desirable and necessary for effective engagement in exploration or investigation - creative scientists are the key to the future. Within the scientific process, children need to exhibit flexibility and independence. Flexibility involves children in being prepared to modify or abandon their line of exploration or investigation when a more fruitful one emerges, and to encompass the views of others. Independence involves children having ideas of their own about the exploration they are involved in; it enables children to move away from the automatic acceptance of the ideas of others, and to make their own decisions based on available evidence and not on someone else's idea. They also need to be persistent and maintain an active interest in their exploration and investigation, and continue an activity or task despite difficulties or lack of immediate success. Objectivity is necessary in order for children to identify variables and undertake fair testing. Without objectivity, the development of scientific skills, concepts and knowledge is impaired. Successful, unbiased interpretation of data also relies on objectivity. Sensitivity towards the views and abilities of other children, but also towards all living things and the environment, is an equally important attitude in scientific exploration or investigation. This involves respect, responsibility and a willingness to care (Harlen 2000:48,49; Johnston 1996:99-101).

- *Reflective attitudes*

Reflective attitudes help children to objectively consider their data, interpret evidence and make tentative hypotheses, but remain flexible enough to change their ideas if these are not consistent with the evidence. Children need to be encouraged to question, wonder, ask "why"-questions and be cautious about accepting things at face value. They need to develop a healthy scepticism. They need to embark on a scientific activity with an open mind, considering the views of others, but without total acceptance of the ideas of others without consideration of their own. Some degree of tolerance on the child's part is indicated when the ideas of others, particularly the teacher's, are respected and not contradicted. Although tolerance for the ideas and interpretations of others is needed, children do not have the ability and confidence to challenge ideas and interpretations that do not match their own. In some cases children seem able to allow two contradictory ideas to exist together without recognising that they are contradictory.

Children need to have respect for evidence whether it confirms or contradicts their ideas. Respect implies that they are not biased in their interpretations because of existing ideas. They also need to realise that if the evidence does not match their ideas and expectations, they may challenge the evidence, but not ignore it; they still need to respect valid interpretations based on the evidence which are not compatible with their own ideas and expectations.

Children need to see that all evidence is tentative, that they can only draw conclusions with supporting evidence, and that even then the conclusions may be subjected to challenge. They also need to be flexible enough to recognise that there may be other ways of looking at evidence, and willing to consider evidence from alternative viewpoints and to change ideas in the light of evidence. Critical reflection on a scientific exploration or investigation is a mature activity that young children find difficult. It involves a willingness to consider alternative ways of undertaking an investigation to improve the outcome, that is, to evaluate procedure. Sharing ideas, planning and interpretations helps to identify different perspectives and gives children access to the ideas of others (Johnston 1996:102-103; Lindt 2000:57).

(b) Attitudes towards science

Attitudes begin to form early in children's lives - the mass media, peer groups and family values all influence children's concepts of and attitudes to science. In the absence of positive primary science experiences, children could develop negative attitudes towards science (Fleer and Hardy 1996:21). Johnston claims that the reasons for developing positive attitudes to science should be considered from different viewpoints: those of the individual, of society, and of science and scientists. A summary of these viewpoints according to Johnston (1996:106-107) follows:

- *From the viewpoint of the individual*

Children should have a positive image of science, that is, a full and accurate picture of its nature and different aspects. A positive image is needed, not to persuade them into science as a career, but to allow them to make informed decisions as to whether science has a part to play in their lives. A full and accurate picture of science assist people in important decision-making; without it, understanding and interpretation of scientific issues within society would be difficult. These decisions may have an effect on the immediate environment or the planet as a whole, for example, a full understanding of how science influences the environment allows people to make personal, local and national decisions (e.g. regarding recycling or disposal of toxic waste). Understanding of genetics and medical science allows people to make informed decisions regarding ethics or desirability of genetic engineering. If attitudes are based on accurate knowledge, they are more likely to be positive than if based on hearsay and innuendo (Johnston 1996:106).

- *From the viewpoint of society*

Positive attitudes to science are important to society at large. The need for greater scientific understanding is emphasised to further good scientific and technological development, which will enable society to understand the effect of science, technology and industry on the environment, and to make ecological decisions. There is also a need for good science graduates, equipped with relevant knowledge and skills, to further scientific and technological advances (Johnston 1996:106).

- *From the viewpoint of science and scientists*

Positive attitudes to science are important in order to dispel the misconception that science is only appropriate for scientists. In the words of Johnston (1996:107): "The mythical scientists are that strange breed of 'men', intelligent, grey-haired, bespectacled, eccentric, with test tubes or leaky pens in their pockets and a bemused expression on their faces, who muck up the environment." Children's artworks of scientists confirm the image they have about scientists and that they do not view themselves as scientists. Good role models in school, and understanding of the significant part science plays in society, will help to change the stereotyped view of science and scientists (Johnston 1996:107). (Compare "Views of a scientist" of the third year students in B Ed (ECD/Foundation Phase), University of Pretoria in Appendix D).

This previous section presented a view of the nature of Natural Science in the early years. Prominent aspects, relevant specifically to young learners, are scientific literacy and the knowledge, process skills, as well as the values and attitudes in science. A prominent place for science in the curriculum can be justified in many ways. In the final section of this chapter, a rationale for teaching Natural Science in the Foundation Phase is presented.

2.6 A RATIONALE FOR EARLY CHILDHOOD SCIENCE EDUCATION

The complex and multifaceted nature of science raises the question whether young children should be exposed to it at all. In a recent study, Eshach and Fried (2005:332) argue that better reasons exist for teaching science to young children than for withholding it from them. Even if that is accepted, the place of science in the curriculum should still be justified, and a rationale for early childhood and primary science should be developed (Fleer and Hardy 2001:37,43). Here, some important elements in developing a rationale for teaching science are provided.

1. *Children naturally enjoy observing and thinking about nature* (Eshach and Fried 2005:332). Children are born with an innate motivation to explore the world. They are doing science, whether introduced to the field or not. They are known to be forming conceptions about their world through everyday experiences. However, these conceptions are often in conflict with scientific views. It is therefore wise to intervene and provide fruitful learning environments, and a scientific outlook, and to assimilate material that will stimulate scientific concept development at a later stage. Science education can also make a significant contribution to the development of the child as a whole (Eshach and Fried 2005:319, 332; Fleer and Hardy 2001:43).

2. *Exposing young learners to science develops positive attitudes towards science* (Eshach and Fried 2005:332). Attitudes to science begin to be formed at an early age. In the absence of positive experiences in science, children could develop negative attitudes. It is therefore essential to provide experiences that will pique their curiosity and spur their enthusiasm. Their attitudes can have a crucial impact on their choices and successes in learning science (Eshach and Fried 2005:319, 332; Fleer and Hardy 2001:46).

3. *Early exposure to scientific phenomena leads to a better understanding of the scientific concepts to be studied later in a formal way* (Eshach and Fried 2005:319, 332). Children should be directly exposed to scientific phenomena in a paced and controlled way. The processes of learning, construction of novel understanding, and making sense of new experiences are all ongoing and all influenced by (and built on) learners' prior existing ideas. Exposing young learners to scientific concepts may help children organise their experiences in such a way that they are better prepared to understand the scientific concepts they will learn in future. Early science education can therefore provide a foundation for secondary education (Eshach and Fried 2005:332; Fleer and Hardy 2001:43).

4. *The use of scientifically informed language at an early age influences the eventual development of scientific concepts* (Eshach and Fried 2005:322-324,332). Language has a significant influence on concept construction. It has the potential to shape experience and the formation of prior knowledge. In some cases, however, tension between everyday language and scientific language may arise. This tension is, however, essential in the learning of scientific concepts, as it is a sign that the process is underway (compare Vygotskian zone of proximal development, par. 3.3.3). Eshach and Fried (2005:332) suggest that exposing children to "science talk" will help them establish patterns of "scientific conversations" which in turn might assist in developing patterns of "scientific thinking" (Eshach and Fried 2005:333).

5. *Young learners can understand scientific concepts and reason scientifically.* Many scientific concepts and theories are hard to understand, even by adults. Are children sufficiently mature intellectually to comprehend scientific concepts? This question remains crucial. Although some research has shown that children lack the required skills to conduct investigations fruitfully, other research demonstrate children to be able to think abstractly about complex scientific concepts. Science education plays a crucial role in exposing children to situations where they can practice their emerging scientific

skills on a level that fit their abilities. Science education programmes should therefore consider the growth of children's understanding of scientific concepts (Eshach and Fried 2005:326,333).

6. *Science is an efficient means for developing scientific thinking* (Eshach and Fried 2005:327-328,333). Not every instance of reasoning or any instance of connecting evidence and theory can be regarded as "scientific". Many so-called *scientific reasonings* happen in everyday, nonscientific contexts. But, according to Eshach and Fried (2005:328), "by beginning with scientific thinking in scientific contexts - and one ought not to forget that the *model* for scientific thinking in any context still comes from science! - children not only learn to be critical and analytical but also learn to see more easily and clearly where other kinds of thinking fails to be 'scientific'".

7. *Science education for young learners can be justified in terms of equity* (Fleer and Hardy 2001:44). Research has shown that there is often a gender differentiation in the area of science where girls often express less interest and perform worse than boys. Inclusive science education for young learners should therefore take in consideration differential experiences and socialisation not only along gender lines, but also along ethnic, racial and social class lines.

8. *Early experiences in science can be a significant way of assisting learners to overcome general learning problems* (Fleer and Hardy 2001:46). Teachers in practice have commented that some learners, especially boys, were assisted to overcome serious language problems by engaging them through their interests in science and technology.

9. *Preparation of a scientifically literate population and future scientists*. One of the major goals of science education is to produce well-qualified scientists who will be the researchers of tomorrow, but also to produce well-balanced individual members of society. Young learners gradually develop scientific knowledge and understanding during the Foundation Phase. Teachers therefore need to provide hands-on science experiences that will encourage exploration, observation, problem solving, prediction, critical thinking, decision-making and discussion, and provide science experiences where knowledge and understanding develops alongside scientific procedures, skills, and attitudes towards and in science (Ward, Roden, Hewlett, and Foreman 2005:1-4).

2.7 CONCLUSION

Chapter 2 offered an inclusive view of what Natural Science means and entails, particularly at the Foundation Phase level. It emerged that science is a multi-dimensional endeavour with complex interrelations with society. On the question “what is science?”, it has been demonstrated that science is much more than “just a book of facts about nature” (Bentley, Ebert and Ebert 2000:11,22). It is essential that teachers develop an understanding of the nature of science, its underlying philosophy and its relation to society and culture, in order to teach it effectively to young learners.

A major goal in science education worldwide is to produce scientifically literate people who can think critically. In the South African context, the Natural Science Learning Area is designed to promote scientific literacy in Foundation Phase learners. The promotion of scientific literacy has as final goal South African citizens who are interested in, and understand the world around them. It should furthermore enable them to engage in the discourse of and about science, to be sceptical and to question other people’s claims on scientific matters. Scientific literacy implies that learners should be able to identify questions and draw evidence-based conclusions, and in the final instance, to make informed decisions about the environment, their personal health and their own well-being. Science education should equip learners with scientific knowledge/concepts, scientific process skills and scientific values and attitudes, in order to promote scientific literacy so that learners can cope in a scientific and technological world (Goodrum, Hackling and Rennie 2001).

The complex and multifaceted nature of science raises the question whether young learners should be exposed to Natural Science education at all. This chapter provides evidence that the reasons for teaching science to young children outweigh by far those that argue for withholding it from them.

In Chapter 3, issues relating to learning and teaching in the Natural Sciences are investigated.

CHAPTER 3

NATURAL SCIENCE LEARNING AND TEACHING

3.1 INTRODUCTION

Effective teaching of the Natural Sciences depends on the teacher's understanding of how children develop intellectually, how they think, what they think about, and how they learn and process information. Learning theorists provided valuable insight into how children learn and think about science, and how instruction influences learning. The focus of this chapter is twofold: In the first part of Chapter 3, issues relating to the *learning* of science are explored, and the second part of the chapter is devoted to the *teaching* of science by investigating a variety of suitable methods.

This chapter start by investigating the views of several educational theories that influenced current perspectives on learning. Thereafter, the focus moves towards science learning in the Foundation Phase. For effective science learning and teaching, various factors need to be considered, for example, how concept formation takes place, the nature of children's personally constructed ideas, the formation and progression of process skills, values and attitudes and the learning characteristics of Foundation Phase learners. These factors are all addressed in this section.

The second part of Chapter 3 is a discussion of various methods, ranging between traditional expository, enquiry-based, and free discovery methodologies. Most teaching methods emerged from the learning theories discussed in the first part of the chapter.

Before some influential learning theories are addressed, two contending perspectives on how children learn are discussed.

3.2 PERSPECTIVES ON LEARNING: BEHAVIOURISM VERSUS CONSTRUCTIVISM

There are two main perspectives on how children learn. In the behaviourist perspective, knowledge is transmitted to children and taken in or incorporated by the child. In the constructivist perspective, knowledge is constructed by children through a dynamic, interactive process (Chaillé and Britain 2003:5). Of the two perspectives, the behaviourist approach is currently regarded as less desirable than the constructivist approach.

Many researchers have shown that educational experiences for young learners should steer away from mere transmission (behaviourist perspective), and towards knowledge construction. Esler and Esler (2001:15) regard the acquisition of knowledge by memorisation to be the lowest level of cognitive activity (Bloom's taxonomy). This includes memorisation of all kinds, whether simple terminology and facts, or principles, generalisations and theories (in other words, rote learning). According to these authors, maximum cognitive involvement occurs when a learner is engaged in finding the solution to a problem that is meaningful and important to him/her. Children should therefore be provided with opportunities to become involved and operate as independent investigators (Esler and Esler 2001:17). This learner-centred approach, where learners are actively involved in the construction of meaning, portrays a constructivist perspective. The constructivist perspective profoundly impacts on how a teacher should approach the teaching of science.

How constructivism developed through a synthesis of influential educational theories, and how knowledge construction facilitates meaningful understanding, are the main topics of this first part of the chapter.

3.3 INFLUENTIAL LEARNING THEORISTS

While *constructivism* is currently the dominant paradigm for thinking about science learning, it is not entirely new. The seeds for constructivism were planted as far back as the beginning of the twentieth century, among others by John Dewey. Contemporary constructivist thinking is a synthesis of several dominant education theories.

Significant contributions to the constructivist theory include:

- Dewey's notion of the nature and importance of direct experience (par. 3.3.1);
- Piaget's view on cognitive development and processing (par. 3.3.2);
- Vygotsky's ideas of assisted learning/scaffolding (par. 3.3.3);
- Bruner's encouragement of appropriate mental actions built from specific experiences (par. 3.3.5) and
- Ausubel's emphasis on formation of mental structures (par. 3.3.6).

Although theories do not inform teachers about specific courses of action, knowing and applying educational theories can help teachers to make observations about learners that might otherwise go unnoticed. For instance, teachers in the primary grades often overestimate the level of understanding of children because of falsely assuming the perceptual abilities of children to be the same as those of adults. Many more reasons exist why teachers should be aware of children's developmental stages and levels of thinking (Carin and Bass 2001: 73; Esler and Esler 2001:19).

In what follows, the theorists most influential in current theory on effective instruction, are briefly examined. While still much remains to be learned, these scholars contributed significantly towards the current body of knowledge on how children learn and think about science, and how instruction can enhance learning.

3.3.1 John Dewey (1859 -1952)

Education is not preparation for life: education is life itself.

The writings and teachings of the American philosopher and educator, John Dewey, profoundly influenced education at the turn of the 20^{th} century. The roots of constructivist science education may be found in the rise of pragmatism and the progressive education movement led by Dewey after World War 1. In contrast to the authoritarian methods of teaching or the behavioural paradigm of the day, Dewey called for programmes that centred on reflective thinking, problem solving and experimenting. He championed the notion of mentally active, hands-on learning (now called hands-on, minds-on learning).

Dewey believed that children learn best when they have to solve meaningful problems where they must investigate, accumulate ideas, process information and put ideas to practical use. People learn by doing and reflecting on what they do. According to Dewey, people use a version of the scientific method to process ideas and solve problems. Basic to his view is the need for direct, rich, meaningful experience for *each* learner.

He also emphasised the role of the community in education: learners should not be isolated, but socialisation is important to assure purposeful activity (Martin *et al.* 1994:34; Bentley, Ebert and Ebert 2000:15,41; University of Pittsburgh:online).

3.3.2 Jean Piaget (1896-1980): Intellectual Constructivism

Jean Piaget, Swiss Psychologist and Biologist, contributed enormously to the understanding of the development of children's thought processes. He and his associates studied the development of cognitive processes in children since the 1920's. The aim of Piaget's work was "to explain the development of intelligence and to comprehend how from elementary forms of cognition superior levels of intelligence and scientific thinking came about" (Marek and Cavallo 1997:34). In other words, he was concerned with the question: "how does knowledge grow?".

Piaget rejected the assumption that children are miniature adults and claimed instead that each particular age range has a distinct quality of thought. The data Piaget and his colleagues collected led to the formulation of a model of intellectual development. According to Piaget's model, people pass through stages of thought during their life span. He postulated four stages of intellectual development, which occur in continuous progression from infancy to post-adolescence. Intellectual development begins at birth; without skipping a stage, a human being progresses developmentally through each succeeding stage. Every stage of learning is necessary for the development of the stages that follow. Thought in each stage has certain properties that differ from those in the other stages, which implies that the *content* children *can* learn at each level is unique. It does not imply that all children in a particular stage think exactly alike, but rather that the thinking of children at the same stage has common properties (Marek and Cavallo 1997:37-38).

It is important to realise that the ages assigned to the various stages indicate when the majority of children are *likely* to reach that particular stage. Individual ages can vary considerably, depending on factors such as maturation, experience, social interaction and equilibration. Culturally deprived children who did not have exposure to a rich environment and experiences, for instance, may reach a certain stage later than that indicated by Piaget. The transition between cognitive stages is not linear: children may use a thought process connected to one stage in a particular situation, but revert to one connected to a different stage in the next (Carin and Bass 2001:86; Marek and Cavallo 1997:38; Gega 1994:22).

Piaget's theory is based on the idea that the developing child builds or constructs cognitive schema/mental structures for understanding and responding to physical experiences within the environment. Intelligence is shaped by experience: every person develops mental processes to deal with incoming data from the environment. Piaget calls these data-processing procedures *mental structures*. Intelligence is not a static attribute, but a dynamic factor which changes through the construction and reconstruction of mental structures and content. As children move through the intellectual stages, they are able to process more and more complex data from the environment. Personally useful knowledge is organised in the memory as schemas (the basic unit of the cognitive structure). Personal schemas contain knowledge that was previously discovered, acquired and constructed. As children grow, they construct more and more schemas, which eventually get integrated with one another and form cognitive structures. As more cognitive structures are built, more data can be incorporated into them and the individual moves through one intellectual stage into the next.

The process of incorporating new experiences and information from the world into existing schemas is called *assimilation*. Connecting new to prior knowledge is an ongoing constructive process. In making sense of new data, children have to modify or adapt their existing structures to *accommodate* the new inputs that do not fit into the current schemas. Learning results from the balanced tension (*disequilibrium*) between assimilation and accommodation. The brain is always striving internally to create balance between assimilation and accommodation. When structures have been adjusted to accommodate new information, the learner has once again reached a state of *equilibrium*. For Piaget, equilibration is the driving force behind the knowledge construction process. For teachers to make the biggest contribution to learners' development, they must encourage the curiosity, persistence and effort that characterise equilibration, motivation and scientific enquiry (Carin and Bass 2001:79,81, 86; Victor and Kellough 2000:45; Marek and Cavallo 1997:58-61).

The four stages distinguished by Piaget are the sensory-motor (0-2), the pre-operational (ages 2-7), the concrete-operational (7-11) and formal-operational (age 11 and up) stages. To this study with its focus on Foundation Phase learning, the pre-operational stage (ages 2-7) and the concrete-operational stage (7-11) are of particular interest. The pre-operational stage is further divided into sub-stages. The stage lasting from four to seven years is known as the *intuitive thought* sub-stage (Gega 1994:22). Since this is the stage at which Foundation Phase learners in South Africa (Reception Year - 5/6 and Grade 1 - 6/7) start their schooling, it will be the primary focus of this section.

(i) The *sensory-motor stage* is the only stage of which the starting point can be precisely stated: it starts at birth and ends at approximately 2½ years. Without discussing this stage in depth, it is important to mention that children in this stage are mainly concrete and active in their learning style and build a set of basic skills and concepts through sensory and physical interaction with the environment. Through their activities young children *assimilate* a great deal of information. Intellectual development begins to emerge - later learning cannot occur unless early learning has been accomplished (Lindt 2000:6; Carin and Bass 2001:38).

(ii) At approximately 2 years, the child enters the *pre-operational stage* (2-7). The stage's name implies that children are not yet able to engage in those particular kinds of thinking referred to by Piaget as *operations*. The concepts they begin to develop are still incomplete and often referred to as *pre-concepts*. Language develops rapidly and is used increasingly to express concept knowledge (Lindt 2000:6). Pre-operational children see, decide, and report. They are described by Carin and Bass (2001:87-88) as excellent observers, explorers and describers of their environment. They tend to still experience problems with classificatory and explanatory inquiries. They think, but thinking about what they think, is beyond their intellectual ability (Marek and Cavallo 1997:40).

A complete description of all the intellectual characteristics of children in this stage cannot be discussed here. The basic characteristics are given in four related areas in the table below.

(iii) The thinking of children in the *concrete-operations stage* (7-11) reveals many differences from the previous stage. There is an entire set of mental operations that begin to become available at around the age of seven. The operations, and the manner in which they are used, are referred to by Piaget as *concrete*, "because they relate directly to objects and not yet to verbally stated hypotheses" (Piaget 1969 in Marek and Cavallo 1997:52). Concrete operational learners cannot yet think abstractly. They do however understand data from reality, from actual objects, events and situations, and from concrete experiences. Therefore, the only way for meaningful understanding to take place, is through actual experience with the concepts to be learned (Marek and Cavallo 1997:53).

Carin and Bass (2001:88,89) describe learners in this phase as organisers and tentative explainers of their environment: "Given the chance through hands-on enquiry activities and teacher guidance, concrete-operational thinkers begin to organize investigations in terms of concepts and variables, measure variables meaningfully, and arrange data in tables and graphs. They can also form and understand simple relationships, use what they know to make inferences and predictions, and generalize from common experiences. The concrete operational years can be especially exciting times in science for children and their teachers". A brief summary of the basic characteristics at this stage are given in the table below.

The period between the ages of 5 and 7 is a transitional period to concrete-operations. As each child develops at his/her own pace, it can normally be expected that some children will already be "conservers", while others are not. Teachers need to take this into consideration as it effects children's ability to deal with abstract symbolic activities (numbers/words) (Lindt 2000:7).

In the TABLE 4 (below), a summary of children's thinking in two Piagetian stages: intuitive thought (4-7) and concrete (7-11) (Corresponds to Foundation Phase, age 5-10) is provided.

TABLE 4: A summary of thinking in the intuitive-thought (4-7) and concrete-operational stages (7-11).

Thought process	**Intuitive-thought (4-7)**	**Concrete-operational (7-11)**
Cause and effect	Logic often contradictory, inconsistent and unpredictable. Explanations for events may refer to magic or human convenience.	Avoid contradictory explanations for events. Make a physical connection between cause and effect. In the last part of this stage, their explanations are logical and show judgement, although they might be wrong.

Relative thinking	Self-centred or egocentric view have an effect on their perceptions and language. Little grasp of how variables (e.g. time, speed, distance) interrelate. Physical properties (e.g. size, texture, volume, etc.) are viewed in absolute, non-relative, ways.	Perceptions of positions and objects are more objective. Aware of others' views. Some understanding of interrelated variables, but only when connected to concrete objects and pictures.
Classifying and ordering	Sorts one property at a time. Little or no class inclusion. Ability to order objects in a series (small-large; thick-thin) grows fast. Trial-and-error ordering in early part of stage, but replaced by a more systematic approach around seven.	Understand class inclusion principle. More consistent and systematic seriation with diverse objects. Can follow successive steps - less discrete thinking.
Conservative thinking	Mostly not able to *conserve*. Perceptions dominate thinking. Centre attention on one variable and do not compensate when the appearance of an object changes. Little or no *reverse* thinking.	Can reverse thinking, consider several variables and compensate. Achieve conservation of number (age 6/7), length and mass (age 7/8), area (age 8-10) and weight (age 9½-10½)

This table was compiled with reference to Gega (1994:239, Appendix E); and Carin and Bass (2001:87).

3.3.2.1 Types of knowledge

Piaget claims that children acquire knowledge by constructing it through interaction with the environment. Knowledge is divided into three areas:

- *Physical knowledge* is formed from external observations and interactions with the physical world and includes learning about objects in the environment and their characteristics, e.g. colour, weight, size, texture, and features of an object.

- *Logico-mathematical knowledge* is a more sophisticated type of knowledge and includes relationships that each individual constructs, e.g. same and different, more and less, number, classification, etcetera to make sense of the world and organise information.
- *Social (conventional) knowledge* is created by people, for example, rules for behaviour in a variety of social settings (Martin *et al.* 1994:38; Lindt 2000:8).

3.3.2.2 How Piaget's theory impacts on science learning

In consequence of what has been said above with regard to cognitive stages and learning abilities, intuitive and concrete-operational children (i.e. Foundation Phase learners) learn best when science activities provide them with opportunities to:

- experience through the senses;
- work with concrete materials;
- think about what they are doing; and
- share their experiences (Gega 1994:40).

3.3.2.3. Multilevel instruction/multitasking

Piaget's theory has taught us that all children follow the same pattern of development. However, teachers must keep in mind that children perceive things differently. Learners in the same classroom will most likely be at different stages of intellectual development and will have their own independent ways of learning. It is important for teachers to be aware of the developmental level of the individual learners in order to personalise the instruction and attend to learners on their individual levels. Multilevel instruction or multitasking - where groups of learners work at different tasks to accomplish the same or different objectives - is a useful and necessary strategy to follow in a classroom (Esler and Esler 2001:25; Victor and Kellough 2000:44).

3.3.3 Lev Vygotsky (1896-1934): Social Constructivism

The work of Vygotsky, a Russian Psychologist and scientist born in the same year as Piaget, was not discovered until the aftermath of the Cold War. He died at age 38, before his life's work could be complete. Vygotsky studied and translated Piaget's work and agreed with him on most points. In contrast with Piaget, however, he emphasized the role of the environment and social influences on cognitive change (University of Pittsburgh:online).

Vygotsky believed that, just as people invented tools such as knives, spears, shovels, etc. to help them master their environment, they also developed mental tools to help them master their own behaviour. For instance, people developed cooperation and communication and new capacities to plan and think ahead. Vygotsky referred to these tools as *signs*. To him the most important sign system is *speech*, as it enables social interaction and facilitates thinking. He also regarded writing and numbering as important sign systems (Lindt 2000:8).

While Piaget looked at development as coming from the child's inner maturation and spontaneous discoveries, Vygotsky believed this to be true only until about the age of two. From this point onwards, culture and cultural signs are necessary to expand thought. Cognitive development is not simply a matter of individual change, but rather a result of social interactions in cultural context (Lindt 2000:9; Marek and Cavallo 1997:94). Vygotsky believed that "what the child can do in cooperation today, he can do alone tomorrow" (Vygotsky,1962 in Carin and Bass 2001: 94). Like Piaget, Vygotsky believed that knowledge is *constructed* as a result of thought and action, but whereas Piaget placed more emphasis on the child's independent knowledge construction, Vygotsky stressed the role of teaching and social interaction in the development of science and other knowledge. He believed that development depends on *biological factors* which produce the elementary functions of memory, attention, perception and stimulus-response learning, but also on *social and cultural factors* which are needed for the development of higher mental functions such as concept development, logical reasoning and judgement. What learners can do and learn thus depends on naturally determined factors, but it also depends on the interaction taking places among themselves and between them and adults (Howe: online).

Vygotsky developed the concept of the *zone of proximal development* (ZPD), which refers to the area between where the child is operating independently in mental development and where he/she might go with assistance from an adult or a more mature peer. Vygotsky agreed with Piaget that learning should be matched in some way to the child's level of development, but he did not define specific abilities of learners within Piaget's four developmental levels.

According to Vygotsky, educators need to know two levels of development of the child:

(1) the *actual* developmental level: the completed mental capabilities and functions of the child, or, in other words, what children can do mentally on their own, without assistance from adults or peers; and
(2) the *potential* developmental level: what children can mentally do with guidance from adults or more capable peers.

Once children are capable of mental functions at the potential developmental level without guidance, they have attained a *higher* developmental level which now becomes their new actual developmental level. The distance between the two levels is referred to by Vygotsky as the *zone of proximal development* (Marek and Cavallo 1997:94-95).

It is important for teachers to discover this "construction zone" or ZPD of learners so that they can provide developmentally appropriate instruction and guide learners to attain their optimal levels of thought. It is the responsibility of teachers to challenge learners and to provide instructional assistance to elevate them to new or higher levels of development. This is called *scaffolding.* According to Vygotsky, good teaching involves presenting material that is a little ahead of a child's development. While they might not understand at first, they would do so eventually, with appropriate scaffolding. This does not mean that instruction should put pressure on development, but that development should be supported as it moves ahead. There are many tools and ways teachers can use to help scaffold learners, for example modelling, questioning, providing clues. However, these tools are only effective when used within the developmental level of the learners. Other initiatives include providing opportunities for working, discussing or displaying their ideas in groups using the language of the discipline (Lindt 2000:9; Carin and Bass 2001:94; Marek and Cavallo 1997:95).

To scaffold the learning process for learners, teachers should:

- "set challenging and interesting learning tasks with an appropriate degree of novelty;
- simplify the task so that the learner can manage its components and achieve intermediate steps;
- facilitate student talk in small group and large group settings;
- ask meaningful questions at just the right time;
- lead students to clarify, elaborate, or justify their responses;

- supply necessary information or direct learners to appropriate sources;
- provide models of thinking processes; and
- provide external support, such as diagrams and concept maps, to aid students in making difficult connections" (Gricorenko, 1998; Roehler and Cantlon 1997 in Carin and Bass 2001:94).

A *social* constructivist theory is based on the notion that individuals are members of specific cultures which are inseparable from their learning experiences. A particular culture promotes and values particular skills, ideas, actions and ways of thinking, which implies that certain ways of thinking and acting are familiar to members of the same culture. There may or may not be common elements among different cultures. Graph making has, for example, a cultural foundation and is valued primarily by more technologically advanced cultures and by certain subcultures, such as the discipline of science. It is thus important for teachers to be aware of the children's zone of proximal development and to understand cultural-significant and cultural-distinctive ways of thinking when planning and delivering the curriculum (Marek and Cavallo 1997:94,96).

Vygotsky's ideas imply a classroom environment where active exchanges occur among children themselves and between children and adults. In such a setting, the teacher sets tasks that are just beyond the learners' current levels of competence and provides the assistance needed to reach higher levels. Teachers include "opportunities for learners to work together, to give and receive verbal instructions, to respond to peer questions and challenges and to engage in collaborative problem solving" (Howe:online).

The ideas of both Piaget and Vygotsky are important in designing developmentally appropriate science instruction (Carin and Bass 2001:95). Piagetian constructivists tend to be concerned about the tradition of pressuring children and not allowing them to construct knowledge freely and independently, while Vygotskian constructivists are concerned with children being challenged to reach their full potential. A combination of Piaget's and Vygotsky's views provides a foundation for instruction that follows children's interests and enthusiasms, while offering intellectual challenges at the same time (Lindt 2000:9).

3.3.4 Robert Gagné: A Behaviouristic Learning Model

Robert Gagné, an American Psychologist, is well known for his hierarchy of learning levels. Gagné's learning theory is based on the notion that all learning must proceed from the simple to the more complex in clearly defined stages. Gagné describes learning as the establishment of a capability to do something the learner was not capable of doing previously. According to Gagné, learning capabilities are cumulative. Learning one particular capability usually depends on having previously learned one or more simpler capabilities. Observable behavioural changes are the only way to infer the occurrence of learning. The lowest level of a learning hierarchy includes very simple behaviours and forms the basis for learning more complex behaviours at the next level (Victor and Kellough 2000:46). The significance of these classifications is that each level of learning requires different types of teaching. The five major categories of learning identified by Gagné are: verbal information, intellectual skills, cognitive strategies, motor skills and attitudes. Each type of learning requires different internal and external conditions, e.g. for cognitive strategies to be learned, the opportunity must exist to practice developing new solutions to problems; to learn attitudes, the learner must be exposed to a credible role model or persuasive arguments (Kearsley:online).

Gagné suggests that learning tasks for intellectual skills can be organised in a hierarchy according to complexity (Kearsley:online). He identifies eight levels in the learning hierarchy, starting with the simplest and progressing to the most complex:

- Level 1: *signal learning*: learning to make a general conditioned response to a given signal.
- Level 2: *stimulus-response learning*: acquiring a precise physical or verbal response to a given stimulus
- Level 3: *chaining* (skill learning): linking two or more units of simple stimulus-response learning.
- Level 4: *verbal association*: chaining with links of verbal units.
- Level 5: *multiple discrimination*: linking individual learned chains to form multiple discriminations, e.g. distinguishing between similar things or phenomena.
- Level 6: *concept learning*: responding to stimuli in terms of their abstract characteristics (such as position, shape, colour, number) as opposed to their concrete physical properties.
- Level 7: *principle learning*: relating two or more concepts.
- Level 8: *problem solving*: application of principles to achieve a goal (Esler and Esler 2001:28; Victor and Kellough 2000:46; University of Pittsburgh:online).

Problem solving is seen as the most sophisticated type of learning. In this process, the learner becomes capable of new performances by using new knowledge. When a problem is solved, new knowledge is acquired, the learner's capability moves forward and he/she is now able to handle a wide range of problems similar to the one solved. Gagné calls the learning taking place a *higher-order principle*, which is the combined product of two or more lower-order principles. In practical terms, it means that when a child has acquired the capabilities and behaviours of a certain level of learning, one may assume that he/she has also acquired the capabilities and behaviours of all prior learning levels. If a child experiences difficulties in the demonstration of capabilities and behaviours at a certain level, the teacher should go back to the lower levels to determine where the difficulty lies (Victor and Kellough 2000:46).

In addition, Gagné's theory outlines nine instructional events and corresponding cognitive processes:
(1) gaining attention (reception)
(2) informing learners of the objective (expectancy)
(3) stimulating recall of prior learning (retrieval)
(4) presenting the stimulus (selective perception)
(5) providing learning guidance (semantic encoding)
(6) eliciting performance (responding)
(7) providing feedback (reinforcement)
(8) assessing performance (retrieval)
(9) enhancing retention and transfer (generalization).

These events should satisfy or provide the necessary conditions for learning and serve as the basis for designing instruction and selecting appropriate media (Kearsley:online).

According to Gagné, the successful practice of scientific enquiry requires two major prerequisites: the children must

- have a broad science background that they can apply in solving new problems; and
- be able to discriminate between a good and a bad idea, or, in other words, between a probably successful and an unsuccessful course of action (Victor and Kellough 2000:49).

Gagné’s behaviouristic model is often employed in programmes (especially languages and mathematics) where learners are expected to master the skills that are in a lower hierarchy before continuing to the next level. The model is also contained in some science programmes (e.g. SAPA: Science - A Process Approach), where learners are required to master the subject matter by working through a range of tasks and objectives arranged in sequential order from simple to more complex (Esler and Esler 2001:28).

3.3.5 Jerome Bruner: Discovery Learning Model

Bruner, a leading interpreter and promoter of Piaget’s ideas in the USA, made significant contributions to our understanding of how children learn, by developing his own theory of intellectual development. Bruner is known for his contribution to inductive or discovery learning (Compare par.3.6.2). Like Piaget, he claims that children pass through sequential stages (or representations) that are age-related and biologically determined. Learning then depends primarily on the developmental level that the child has reached.

Bruner’s theory of how children construct knowledge involves three major sequential stages or representations (ways of knowing):

- *enactive representation* (corresponds to Piaget’s sensori-motor stage): knowing which is related to movement, e.g. through direct experience or concrete activities;
- *iconic representation* (corresponds to concrete operations stage): knowledge that is related to visual and spatial or graphic representations, e.g. films and still visuals;
- *symbolic representation* (corresponds to formal operations stage): knowing that is related to reason and logic, e.g. use of words and abstract symbols.

(Victor and Kellough 2000:46-47; University of Pittsburgh:online)

Although Bruner's three representations correspond to the Piagetian stages, he was evidently also influenced by writers such as Vygotsky, since he differs from Piaget in his interpretation of the role that language plays in intellectual development. He believes that the development of new mental structures is more closely associated with language and prior experiences than with the quest for cognitive equilibrium. Whereas Piaget believed that thought and language are different systems (although related), Bruner maintains that thought is internalised language; the child translates experiences into language and use language as an instrument of thinking.

The views of Piaget and Bruner also differ concerning the child's readiness to learn. While Piaget concluded that children's readiness depends on maturation and intellectual development, Bruner and other researchers are of the opinion that a child is always ready to learn a concept at some level of sophistication. According to Bruner, any subject can be taught effectively in some intellectually honest form to any child at any stage of development, but that concepts can only be learned within the framework of the stage the child is in at the given time. Teachers must assist children to pass progressively from one stage to the next by providing challenging and usable opportunities and problems which would persuade them to forge ahead into the next stage in order to acquire higher levels of understanding (Victor and Kellough 2000:46-47; University of Pittsburgh:online).

The act of learning, as described by Bruner, involves three simultaneous processes:

- acquiring new knowledge;
- manipulating the acquired knowledge to fit new tasks or situations; and
- evaluating the acquisition and manipulation of the knowledge (Victor and Kellough 2000:48).

Bruner found discovery activities particularly valuable because they:

- *increase intellectual potency and help children learn how to learn.* Learners develop skills in problem-solving enabling them to arrange and apply acquired knowledge to new situations and thus learn new concepts;
- *are intrinsically motivating.* The motive for learning shifts from extrinsic (source of motivation lies outside the task) to intrinsic rewards (source of motivation lies within the learner and the task itself/internal self-rewarding satisfaction);
- *develop strategies of discovery.* Meaningful learning is not a passive process; according to Bruner, children are actively involved in the learning process. Through the methods of discovering things independently and the process of searching and solving problems, children learn strategies of enquiry or discovery. The more they are involved in solving problems, the more effective their decisions will become and the quicker the solutions;
- *improve memory processing.* The knowledge acquired from discovery learning is more easily remembered and more readily recalled when needed. The knowledge learners acquire in problem solving contexts will also more likely be applied to new situations. Learners remember that which they discover independently, while the information they are told is more readily forgotten. Discovery and hands-on learning activities are therefore important in science teaching and learning (Victor and Kellough 2000:48; Carin and Bass 2001:130,131).

Gagné and Bruner placed different emphases on their approach to learning, which can be presented schematically as follows (Victor and Kellough 2000:48, summarised, tabled):

TABLE 5

Gagné	**Bruner**
• Focus on the product of learning (knowledge) • Key question: "What do you want the child to know?" • Emphasis on learning itself - whether through discovery, review or practice.	• Emphasis on the process of learning (skills) • Key question: "How do you want the child to know?" • Learning by discovery - The *method* is important.
• Hierarchy of learning: the lower learning levels are prerequisite to the highest level; • Sequence in learning, starting from simplest (lowest level) towards problem solving (more complex/highest level).	• Begins with problem solving which leads to development of necessary skills. • Learners are motivated to solve problems and in the process develop the needed skills.

The two scholars also differ in their view of readiness for learning. While for Piaget readiness depends on maturation and intellectual development, Bruner says that a learner is always ready to learn a concept at some level of sophistication. In Gagné's view, readiness depends on the successful development of lower-level skills and prior understandings (Victor and Kellough 2000:48).

Gagné, Bruner and Piaget agree that science should be taught and learned as a process of discovery. Getting practice in discovery involves learners in opportunities to engage in inductive thinking, hypothesising and hypothesis testing in numerous situations in and outside the classroom. Hands-on discovery strategies are equally important to changing learners' misconceptions in science (Victor and Kellough 2000:49).

3.3.6 David Ausubel: Meaningful Verbal Learning

The most important single factor influencing learning is what the learner already knows

According to the educational psychologist, David Ausubel, people acquire knowledge primarily through *reception* rather than through discovery. Against Bruner's discovery learning, he described an alternative method of instruction called *reception learning*. This model suggests that the learner receives ideas through transmission: Concepts, principles, and ideas are not discovered, but presented and understood. He agrees with other psychologists that the development of problem solving skills is the ultimate goal in teaching. However, like Gagné, he upholds that children will more likely acquire effective problem solving and discovery skills after they have learned key and supporting concepts. This happens through reception learning or direct instruction, or, to use Ausubel's term, expository teaching (Compare par. 3.6.1 and 3.7.2). It is consequently the responsibility of the teacher to structure learning, select appropriate materials for learners, and present them in a well-organised fashion. The more organized and focussed the presentation, the more thoroughly the individual will learn.

Ausubel was particularly concerned with how learners turn verbal/textual knowledge presented to them in a school setting into *meaningful knowledge*. According to his approach, meaningful learning results when children relate new ideas, concepts, and information to what they already know. Information acquired from expository instruction can only be turned into meaningful learning when it is connected to the learner's prior knowledge. Using learning situations and examples that are familiar to learners, help them assimilate the new information with what they already know, making the learning more meaningful. Rote learning is not considered by Ausubel as meaningful, since memorisation omits the connection of new knowledge with existing knowledge.

Before entering into the expository lesson, Ausubel dictates the use of a major instructional mechanism, which is also his most famous contribution to cognitive educational psychology: the *advanced organiser*. The advanced organiser is an abstract introductory statement to the new body of knowledge or content that will be presented to the learners. This provides a framework for the assimilation of new ideas and mentally prepares learners to integrate new material into previously built cognitive structures. Advanced organisers are different from overviews and summaries (which simply emphasise key ideas in an arbitrary manner), but they act as a subsuming bridge which connect new material with prior learning. Through this strategy, verbal learning is linked to prior knowledge, avoiding learning by rote and making learning meaningful and longer lasting. Advanced organisers should be assembled, organised and sequenced, in order to support the main principles, key concepts and facts which are to be learned (Victor and Kellough 2000:49-50; Marek and Cavallo 1997:97-98; Carin and Bass 2001:132,133; Tomei:online; Telkamp:online)

The cognitive research of learning theorists have contributed immensely to our understanding of how children learn and process information. Naturally, the insights also apply to how instruction can influence science learning. It should always be kept in mind that people differ and learn in a variety of ways. There is not one single way in which learners in a classroom receive and process information: they have different ways of knowing and constructing knowledge, they have different skills and talents, different styles of learning and working and different temperaments. It is unfortunate that many schools still operate as if all learners are identical, and teach and assess only a limited number of abilities. Recently, much research has been focused upon the field of multiple intelligences and learning styles. These aspects will be explored in greater detail in the following sections.

3.4. LEARNING STYLES AND MULTIPLE INTELLIGENCES

The world-renowned scientist Albert Einstein was a daydreamer. His teachers in Germany are said to have told him that he would never amount to anything, that his questions disrupted class discipline and that he would be better off out of school. Nonetheless, he became one of the greatest minds in world history. Obviously, his learning style was at odds with the style acceptable to his school. Recent research claims that the same mismatch continues for millions of learners even today, and might be the biggest single cause of failure in the school system (Dryden and Vos 2001:341).

Victor and Kellough (2000:57) note two important aspects regarding multiple learning styles:

- Intelligence is not a fixed reality but can be learned, taught and developed.
- Learners learn and respond to learning situations in different ways. The particular situation, ethnicity, culture or socioeconomic status may influence the way they learn.

3.4.1 Multiple Intelligences

As noted above, intelligence is not a fixed entity: each person has access to many different intelligences or intelligence traits (Dryden and Vos 2001:343). Dryden and Vos claim that, in order to revolutionise the world's school system, each learner's combination of learning styles and talents should be identified and catered for, together with boosting the well-rounded development of all potential abilities. Recently, Howard Gardner, Harvard professor in Education, has pioneered breakthroughs in shattering the "fixed IQ" myth, by defining different *intelligence centres* that each person has. The findings of Gardner are of vital importance to planning the future of education and classroom practice.

3.4.1.1 Howard Gardner's Theory of Multiple Intelligence

Howard Gardner's theory of *multiple intelligences* or *learning capacities* can lay claim to being the most broad-based theory of learning styles. Gardner defines intelligence as "the capacity to solve problems or to fashion a product which is valued in one or more cultural settings" (Edwards 2000:235). In his initial list of 7 intelligences, the first two are the ones that traditional learning focuses on; the next three are associated with the arts and the final two are called the personal intelligences.

The capacities thus far identified are:

(1) *Linguistic intelligence*: sensitivity to spoken and written language, the ability to learn languages and the capacity to use language to accomplish certain goals.
(2) *Logical-mathematical intelligence*: capacity to analyse problems logically, carry out mathematical operations and investigate issues scientifically.
(3) *Musical intelligence*: Sensitivity to pitch, melody, rhythm and tone; skill in performance, composition, and appreciation of musical patterns.
(4) *Bodily-kinaesthetic intelligence*: ability to use body and handle objects skilfully.
(5) *Spatial intelligence*: ability to perceive visual-spatial world accurately and manipulate the nature of space.
(6) *Interpersonal intelligence*: ability to understand people and relationships.
(7) *Intrapersonal intelligence*: ability to access one's emotional life in order to understand oneself and others (Victor and Kellough 2000:55-56; Casacanada:online).

The preceding list was provisional; a decade after Gardner formulated the theory of multiple intelligences, he revisited his theory and found at least one more ability that deserved to be called an intelligence:

(8) *Naturalist intelligence*: ability to recognise and classify plants, minerals, and animals, including rocks and grass and all varieties of flora and fauna.

As this study has special interest in the study of nature, a further explanation of the eighth intelligence seems justified.

Gardner explains naturalist intelligence as an ability human beings need in order to survive: it derives from the need of primitive humans to distinguish between animals suitable for hunting and those which should be avoided. Brain evidence supports the existence of the naturalist intelligence: certain parts of the brain are particularly dedicated to the recognition and naming of "natural" things. Children possessing naturalist intelligence may have a strong affinity to the outside world or animals and enjoy topics, games, shows and stories that deal with animals or natural events. When these children enter the primary school (Foundation Phase) they may exhibit an unusual interest in subjects areas like biology, zoology, botany, geology, meteorology, palaeontology or astronomy. As young children, they enjoy collecting and classifying or reading about items from nature, such as rocks, fossils, butterflies, feathers and shells. They easily learn characteristics, names or any information on their interests about the world (Edwards 2000:236; Wilson 1997:online).

In a classroom setting, naturalist intelligence can be fostered and developed in various ways, for example by:

- encouraging children to see patterns in nature;
- exploring the sensory elements in nature, such as sounds, smells, taste and feel;
- providing outdoor activities such as nature walks or gardening activities to observe nature and natural phenomena;
- bringing animals into the classroom and teaching children to care for them;
- encouraging collections of natural objects in the classroom;
- provide children with materials/books about nature, science and animals; and
- providing children with information about endangered species (Edwards 2002:236).

3.4.1.2 The impact of Gardner's theory on leaning

Although some significant objections and questions have been raised with regard to Gardner's theory, it has exerted tremendously positive influence on education. It encourages educators to reflect on their practice while giving them a basis to broaden their focus and to attend to assisting people to live their lives well. It leads educators to realise that learners think and learn in many different ways, which in its turn spawned the development of new approaches to better meet the needs of learners.

In a nutshell, Gardners' approach entails:

- *A broad vision of education.* Teachers need to attend to all intelligences, as all seven (and more) are needed to live life well and not only the traditional two.
- *Developing local and flexible programmes.* The immediate educational context must be taken into account and must allow for deep understanding, performance exploration and creativity. According to Howard, a too rigid curriculum or too narrow assessment can undo a "Multiple Intelligence/MI-setting".
- *Considering morality.* Gardner is concerned with how intelligence and morality can work together to create a world in which a variety of people will want to live (Infed:online)

3.4.2 Learning and thinking styles

Educational literature describes many different styles of learning and thinking. A learning style is not an indicator of intelligence, but rather provides an indication of *how* children learn. Learning styles are often classified by function. Individuals use a variety of modes of perception, prefer various environments, are motivated by different things, express themselves uniquely, and prefer various levels of mobility while learning (Victor and Kellough 2000:55; Martin *et al*. 1994:270).

Dryden and Vos (2001:347-348) found that, generally speaking, a learning style is a combination of the following factors:

- *How information is perceived most easily.* Learning through visual, auditory, kinaesthetic or tactile means or whether a learner learns best by seeing, hearing, moving, touching.

- How information is organised and processed. The discovery that the left and right hemispheres of the brain are capable of two different modes of information perceiving and processing, has profound consequences for classroom practice. Learners with predominantly left brain traits, take information in logically and absorb it easily if presented in a logical, linear sequence. Learners with right brain dominance take in information globally and prefer presentations that involve visualisation, imagination, music, art and intuition. If the powers of both hemispheres are used, information will be absorbed and processed more effectively.

- *The conditions that affect the intake and storage of information.* Conditions such as emotional, social, physical, and environmental circumstances that are necessary to help a learner take in and store information.

- *How information is retrieved may be totally different from the way the information is taken in and stored.*

Learning and thinking styles can be classified in terms of preferences of children:

- *visual* = prefer to perceive by seeing;
- *auditory* = prefer to perceive meaning by hearing;
- *bodily kinaesthetic* = prefer to be hands-on and actively involved;
- *individual* = prefer to work alone;
- *group* = prefer to work with at least one other child;
- *oral expressive* = can easily tell and explain their ideas and opinions; they may know more than they can reveal in written format (test);
- *written expressive* = write fluently (essays and answers in tests); thoughts are better organised on paper than orally;
- *sequential* = are able to arrange thoughts and ideas in a linear, organised manner
- *global* = are able to be spontaneous, flexible thinkers; may be intuitive and order thoughts randomly, preferring to do things in their own way (Martin *et al.* 1994:271).

Learners do not fit exclusively into one style, but may share strong preferences across a variety of styles. Learners are served better when learning opportunities are provided in multi-sensory, multi-expressive, and multi-environmental modes.

Evidently, a teacher's *teaching style* has a profound effect on how children learn. Conventional learning experiences, which focus on the linguistic and logical mathematical intelligences, do not cater for the spectrum of individuals an educator is likely to find in a classroom. Learners with strengths in learning through the other intelligences, for example, through active movement and concrete activities (bodily kinesthetic) or through interacting with peers (interpersonal) or through any of the other capacities, will not learn effectively through traditional methods of instruction. These learners will, for example, benefit from peer tutoring and group projects (Lindt 2000:19,20). Learning science in a variety of ways encourages personal learning styles.

Teachers should try to learn as much as possible about each learner and their preferred styles of learning, and develop a flexible, adaptable and multifaceted teaching style. Teachers should teach in ways that capitalise on learners' preferred learning styles. Learning styles can be identified by making use of the several methods of identification currently existing (Dunn and Dunn, in Dryden and Vos 2001:341). In planning learning experiences for young learners, it is essential that teachers consider individual and culturally determined styles of learning. Children benefit when they are initially taught by means of their preferred style: this puts them in a position of strength, enabling them to be exposed to other styles to expand their repertoire (see par. 3.7.10: The Learning Style Model). Teaching through accommodation of different learning styles helps teachers to reach each individual (Martin *et al.* 1994:49,50; Victor and Kellough 2000:57).

Another way to reach the variety of learning styles, is by integrating the various areas of the curriculum, rather than teaching each area in isolation. The diversity in modality-related learning styles is, however, not the only important consideration in planning and instruction. Diversity in race, ethnicity, social class, gender and outside school experiences should also be taken into account (Lindt 2000:20).

The next section focuses specifically on the process of learning science. Two issues are particularly important: how children make sense of new experiences, and how ideas are developed to explain new experience. Children's construction of their own, non-scientific theories and ideas is also considered.

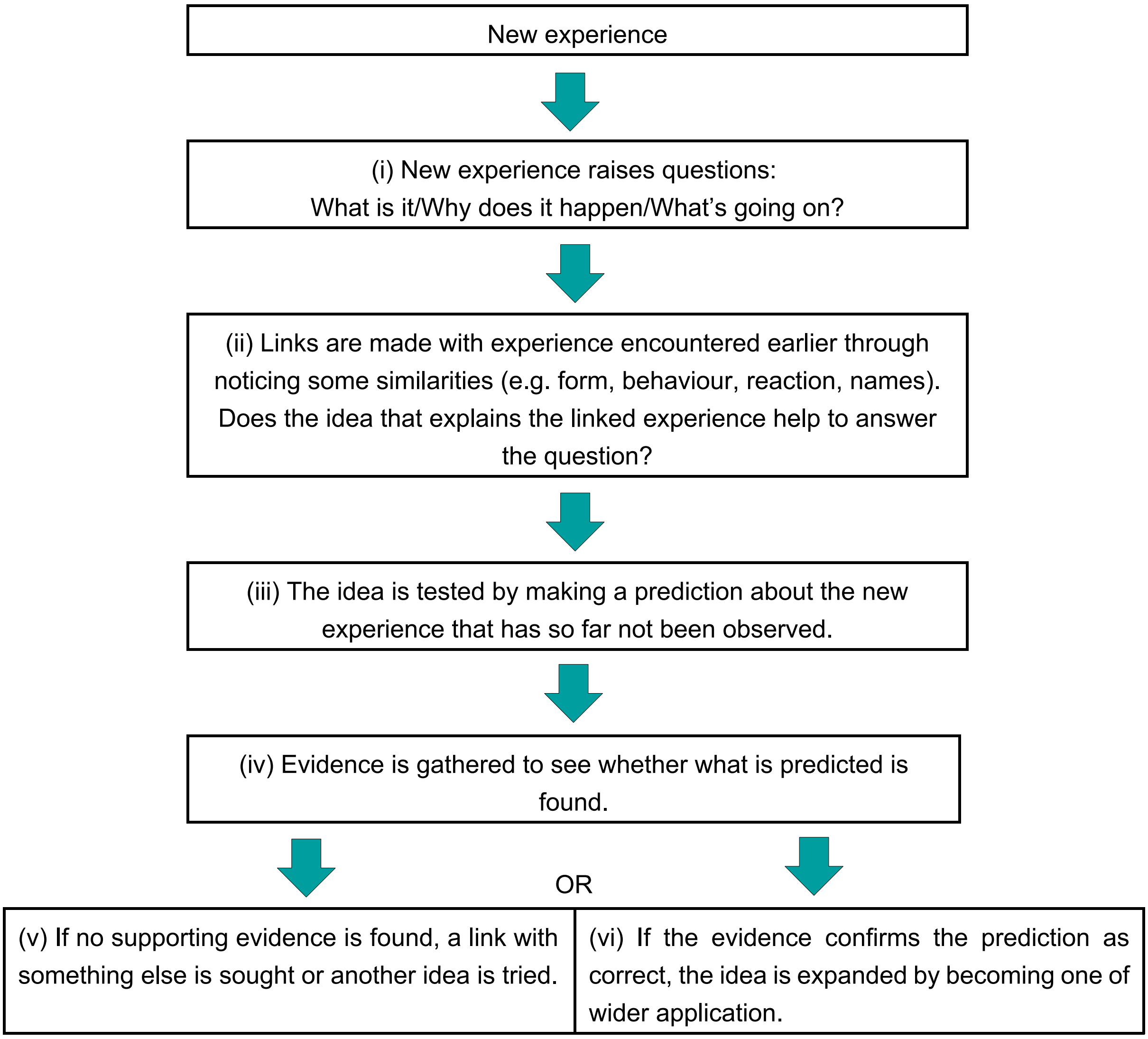
3.5 KNOWLEDGE CONSTRUCTION: HOW CHILDREN ACQUIRE SCIENTIFIC KNOWLEDGE

How do children construct their knowledge of a subject field? It is self-evident that people "know" a lot of things, but that not all of this "knowledge" is useful. Knowledge must first have *meaning* before it can become useful (Marek and Cavallo 1997:35). When people interact with a new object, event, or situation, they participate in all aspects available to them. They select what they believe are the most noticeable facts, ideas, and relationships from that interaction, and put them all together into a whole that is meaningful to them. The complexity of that meaningful whole will, of course, change as a person's experience grows. The knowledge gained from this kind of interaction is usable with new objects, events or situations, because understanding was constructed from the interactions. This meaningful understanding is personal - people construct their own understanding even if they are instructed as to what and how they should "know". The part that remains is the knowledge and understanding constructed by the person himself. Learners should therefore be given the opportunity to engage in *knowledge construction*.

It is generally accepted that learning amounts to more than the mere accumulation of information. Integration of learning across disciplines is one way of addressing the issue of meaningful knowledge acquisition in diverse classroom settings. Because of the diversity of learners in today's classrooms, it is more effective and long-lasting to integrate learning in each discipline into the whole curriculum and make it meaningful to children's daily life experiences, than to teach it as an isolated subject at the same time each day (see par. 4.2.3.1). In contrast to the past emphasis on covering the prescribed material, modern methodology aims at learning as a personal process by which learners build on their personal knowledge and experiences. In this way learners gain real understanding: "meaningful learning is learning that results when the learner makes connections between a new experience and prior knowledge and experiences that were stored in long-term memory" (Victor and Kellough 2000:39).

To illustrate the above, Harlen's *framework for learning in science* (2000:54) is illuminating (See DIAGRAM 2):

DIAGRAM 2: FRAMEWORK FOR LEARNING IN SCIENCE



For meaningful learning to occur, teaching should start at where the learners are, building on their prior experience, and knowledge and correcting misconceptions they might have while constructing their knowledge. It is less important to assess what learners can *repeat* than what they can generate, demonstrate or exhibit. The aim of meaningful learning places a tremendous responsibility on the shoulders of the teacher, because it depends on effective instruction and understanding of how children construct knowledge.

According to Victor and Kellough (2000:40), the instructional task of a teacher is twofold:

- to plan for and provide hands-on experiences, supplying the materials and the supportive environment necessary for meaningful learning and discovery;
- to facilitate the most meaningful and longest lasting learning possible.

Establishing and maintaining a learning environment that is conducive to science learning is a priority for teachers. However, as seen previously, this is not an easy task. Traditional teaching methods are often difficult to discard, and sustained change takes a long time to establish. Learners also might have difficulty adapting to an environment in which they are given the responsibility for making sense of scientific content and constructing their own meaningful understanding when they are used to learning by rote (Lorsbach and Tobin 1997). Teachers should evidently be well versed in the use of varied and developmentally appropriate methods of instruction. The issue is treated in more detail in the second part of this chapter (see par. 3.6). Here, we need to establish how children learn and construct understanding.

3.5.1 Acquiring science concepts

In order to successfully construct meaningful knowledge, children need the building blocks required for the process of construction. In science learning, the building blocks that children need to acquire, consist mainly of *concepts.*

3.5.1.1 Concept formation

All children learn, even should they not attend any school. Their quest for knowledge derives from a need to make sense of the world around them. Concept development begins when an infants start exploring its world with the senses at its disposal, in order to find out all about the environment. The development of concepts continues throughout one's lifetime.

Concepts are initially formed through the concrete experiences of young children. They use their senses and their muscles to learn about their world. As they explore their world through physical movement, their first concepts are closely related to those movements. Concepts such as those of distance and space cannot be formed without a firm basis in concrete experiences. Early concepts are mainly formed in the subconscious mind, but they start to be formed consciously when children are able to connect language to their discoveries, or when verbalised by an adult. Language acquisition and concept formation are therefore closely related. Early concepts are also extremely egocentric. As young children grow and develop physically, socially and mentally, and their experience and knowledge structure broaden, their concepts grow and develop as well. Through growth and maturation, their concepts gradually become less egocentric (Charlesworth and Lindt 2003:3; Van Staden 2003:20).

3.5.1.2 The function of concepts in knowledge construction

A concept allows a person to organise and categorise information. Concepts can be viewed as a type of filing system in the brain under which experiences, facts and knowledge are sorted for later use. While there are countless categories of concepts, such as subject-specific concepts, mathematical concepts, culture-specific concepts and so on, they can all be traced to basic, concrete experiences during the early years. Concepts can therefore be defined as *organisers of human experiences and knowledge* (Van Staden 2003:20).

3.5.1.3 Concepts in the Foundation Phase

Mathematics and science in the early childhood development phase (0-9) are interrelated and therefore share many fundamental concepts. Mathematical concepts such as comparing, classifying and measuring, for example, are needed to solve problems in science, where they are referred to as *process skills.* Conversely, science process skills are equally important for problem solving in mathematics as well. The concepts and skills of mathematics and science are often acquired as children engage in everyday experience and in early childhood activities: playing with blocks, water, sand, and manipulative materials, dramatic play, cooking and outdoor activities (Lindt 2003:4). The list of basic concepts shared by mathematics and science include one-to-one-correspondence, number sense and counting, logic, sets and classifying, comparing, shape, spatial sense, and parts and wholes (Lindt 2000:88-111). These lean more towards the mathematical side; the core *science concepts* children need to acquire in the Foundation Phase are discussed in Chapter 4 (see par. 4.6.4.1).

Understanding occurs when a concept or procedure becomes a real part of the mental structure. Children learn with understanding when they actively construct knowledge and discover new relationships while they explore meaningful and familiar environments. Teachers need to build upon this constructed knowledge and support learners as they move to higher levels of understanding (Lindt 2000:5,16).

3.5.1.4 Progression in concept formation

During the early childhood phase (0-9), young children start forming the concepts which are basic to science and mathematics. Apart from constructing new concepts, they also expand on existing ones, and they develop the processes enabling them to apply their newly acquired concepts. By the time of entering primary school, children apply these early basic concepts to understand and explore more advanced concepts. As a result of growth and experience, the concepts available to young learners also grow and develop (Lindt 2003:2-3). Their scientific ideas develop gradually as they become more mature.

According to Harlen (2000:32), progression indicates "the natural starting point for young children and the directions in which their learning should take them."

Harlen (2000:23-24) differentiates between the following dimensions of progression in children's scientific ideas:

- *From description to explanation*

The scientific ideas of younger learners (5-8) are related to gathering information, and finding out about phenomena. Older learners (8 and above) can combine intellectual activity with facts gathered through enquiry, in order to *explain* an event (Dyasi 1999:10; Harlen 2000:23).

- *From small to big ideas*

Young children's everyday experiences lead to small ideas to make sense of a specific event. When these small ideas are linked to other ideas, they are transformed (progression takes place) into a bigger idea to make sense of new experiences.

- *From personal to shared ideas*

Young children are egocentric in their views and this is reflected in their ideas. As they become older, they negotiate meaning with peers and adults, and their ideas are constructed on the basis of social and educational interactions, as well as their own thinking.

3.5.1.5 The role of the process skills in concept formation

Process skills have a crucial part to play in the development of ideas at all stages. The role of the process skills is to link and test existing ideas. They are used to determine whether accepted ideas actually fit the evidence (see Harlen's framework in par. 3.5). This is an important reason why children should be helped to develop and use their process skills: if the skills are not tuned to the point of being *scientific*, ideas will not be properly tested and may be retained when they do not really fit the evidence (Harlen 2000:57, 63).

Children are continuously and actively engaged in making sense of their world. Because their thinking and reasoning are still immature, they often form ideas that do not accord with the scientific view of things. Children's own scientific ideas will be explored in the following section.

3.5.2 The nature of children's ideas in science

Children-as-scientists are curious about the world around them. In their attempt to understand, they rely on their experiences, their current knowledge and their language. The ideas they form are consequently often at odds with accepted scientific views and could be regarded as "non-scientific". These ideas, which may be referred to as *children's science* (Osborne and Freyberg 2001:13), should be taken into consideration by curriculum developers, teachers and researchers, since they impact on effective science teaching and learning: *"...*unless we know what children think and why they think that way, we have little chance of making any impact with our teaching no matter how skilfully we proceed" (Osborne and Freyberg 2001:13; *cf*. Harlen 2000:57).

What do these self-manufactured ideas typically look like? Osborne and Freyberg (2001:12) provide some general findings regarding children's ideas in science:

(1) "From a young age, and prior to any teaching and learning of formal science, children develop meanings for many words used in science teaching and views of the world which relate to ideas taught in science.

(2) Children's ideas are usually strongly held, even if not well known to teachers, and are often significantly different to the views of scientists.

(3) These ideas are sensible and coherent views from the children's point of view, and they often remain uninfluenced or can be influenced in unanticipated ways by science teaching".

Summarised in generalised terms, children's science has the following typical characteristics (Osborne and Freyberg 2001: 55-56):

- Children have limited abstract reasoning skills.
- They tend to take a self- or human-centred point of view.
- They endow inanimate objects with human or animal characteristics.
- They focus on the entities and constructs from their everyday experiences.
- They are interested in customised explanations for everyday observables rather than coherent scientific theories.
- Their interests, thinking processes and constructions of meaning are inescapably limited by their cognitive maturity, experiences, language, and knowledge and appreciation of the experiences and ideas of others.
- When exposed to scientific explanations, they can only generate meanings from their own views of the world and their own meanings for the language used in those explanations.

Because of the immaturity of their process skills, children are likely to:

- take account of only those factors they see as relevant;
- consider things only from their own point of view;
- make inappropriate links;
- make immature predictions (merely restating what is already known); and
- use evidence selectively to support an existing idea, ignoring contradicting factors (Harlen 2000:57).

Teachers need to understand the ideas of children and take them seriously. More scientific ideas should advance from the already existing ideas that children formed themselves (Harlen 2000:63).

3.5.2.1 Children's non-scientific ideas and misconceptions

A *misconception* is explained by Bentley, Ebert and Ebert (2000:78) as "a belief expressed by a child that is incorrect from the perspective of the scientific community". Other terms used in literature to describe the same phenomenon include *incomplete understanding*, *preconceptions*, *naive theories*, and *alternative conceptions*.

As seen previously, children learn from their everyday interactions and explorations and are constantly interpreting their environment: gathering facts, developing explanations and making predictions. They also learn from other sources, such as their parents, peers and teachers, from events observed through the media, from outings to museums, zoos, concerts and sporting events (Carin and Bass 2001:83; Osborne and Freyberg 2001:55). As children construct their own knowledge, they inevitably come to school with their own understanding of how the natural world works. Their understandings of science concepts or topics will most likely be divergent and will include, not surprisingly, many *misconceptions*.

Although often incomplete or even incorrect, children's ideas, interpretations or knowledge constructions do make sense to them. They bring their own meaning to the world and their interpretations are personally adequate and real to them since being based on personal experience and available evidence. Such ideas are the products of reasoning, albeit limited and representing the child's level of logical thinking. If just ignored, children will hold on to them, since these non-scientific explanations often seem more rational to them than the scientifically accepted equivalents (Osborne and Freyberg 2001:55; Bentley, Ebert and Ebert 2000:73; Lindt 2000:65; Harlen 2000:63).

Although some misconceptions can be corrected immediately, others have to wait for the child's cognitive level to mature. This presents another reason why teachers have to be knowledgeable about children's learning. Teachers have to meet children at their present developmental level and not try to push, pull or drag them to another level by trying to teach concepts they are still ill-equipped to integrate (Osborne and Freyberg 2001:55; Bentley, Ebert and Ebert 2000:73; Lindt 2000:65).

3.5.2.2 Conceptual change

As misconceptions may influence future learning, teachers have the important task of establishing what learners think or believe before science teaching starts. Teachers have to identify misconceptions and design lessons to specifically address those non-scientific ideas, and help learners move towards accepted scientific understandings. Challenging and altering misconceptions are preconditions for more accurate concepts and explanations to be established (Bentley, Ebert and Ebert 2000:78).

Carin and Bass (2001:83) maintain that "what learners already know and believe is a powerful determiner of what they observe from experience, what they select and represent for processing, how they organise new information, and how they make sense of what they encounter". The ideas held by children not only affect the way they make sense of new information, but can also remain intact throughout new instructional settings and can persist even when faced with counterevidence and arguments. Scientific explanations are often too different from children's viewpoints or the beliefs that they already hold, so that the true explanations are unattractive alternatives. Children will only feel compelled to change their ideas when the present ones become unsatisfactory. Even then they might not find enough reason to fully discard the obsolete ideas (Bentley, Ebert and Ebert 2000:75).

For conceptual change to occur, learners have to be confronted with the fact that their personal theories are in conflict with accepted scientific views, and that their ideas are inadequate, incomplete or inconsistent with scientific evidence. They need to be convinced that alternative, scientific explanations exist which are more compelling, encompassing and more in line with reality than their own notions (Carin and Bass 2001:83).

3.5.2.3 Teachers as "change agents"

Teachers as *change agents*, as referred to by Bentley, Ebert and Ebert (2000:75), need to be aware of conditions necessary for changing a child's mind or accepting a different conceptualisation. The conditions for conceptual change are as follows (Smith 1991, in Bentley, Ebert and Ebert 2000:75):

- learners must become dissatisfied with their current understanding;
- learners must have an intelligible alternative available;
- the alternative must seem plausible to the learner; and
- the alternative must seem fruitful to the learner.

Altering or replacing concepts is not an easy task. It often requires time, understanding, patience, and creativity from the teacher. It is furthermore dependent on the developmental maturity of the child (Martin *et al.* 1994:30; Carin and Bass 2001:81-85; Gega 1994:45; Victor and Kellough 2000:41). The interactive method (see par. 3.7.9) or more appropriately called, the *conceptual change teaching method*, can be used to alter children's misconceptions.

3.5.3 Acquiring scientific process skills

In the previous section, the acquisition of concepts/knowledge was discussed. Scientific knowledge always involves using science process skills, because process skills relate to content. The acquisition and development of the process skills should therefore receive the attention they deserve.

As a result of their natural curiosity and their desire to investigate their world, children begin to develop investigative process skills at an early age. The teaching and learning of science therefore involves the development of a range of process skills that are indispensable to children's quest to understand the world around them. The process of investigation in the classroom, is the same as the one conducted in the scientist's laboratory. Although the investigative process will require the use of resources (equipment and materials), these need not to be conventional laboratory equipment and materials. In the Foundation Phase, learners need to work with familiar objects, tools and materials taken form their everyday world (WCED 2003:10). The *process of investigation* is central to the Natural Science Learning Area. Learners will develop these scientific process skills when they are provided with learning experiences in an environment that supports creativity, responsibility and growing confidence (DoE (b) 2002:4).

Process skills are essential in enabling children to develop understanding, and to identify and use relevant scientific evidence in making decisions and in solving problems. As seen in Chapter 2, children are not born with these skills: they need to be acquired. The development of science process skills is therefore an important aim of science education. Separate process skills were discussed in Chapter 2 (see par. 2.5.3.2). In this section, the overall changes that can be regarded as *progress*, will be explained.

Harlen distinguished three dimensions of change (or progress) in process skills (2000:32-33):

- *From simple to more elaborate*

  This dimension comprises progress in the ability to perform more aspects of a skill. For example, in the case of *observing*, it moves from observing main features towards more detailed observation. Or, in *predicting*, to make progress from predicting in value terms to more specific prediction. Or, from concluding that one variable affects another, to being able to identify the direction and nature of the relationship.

- *From effective use in familiar situations to effective use in unfamiliar situations*

  Some scientific knowledge is always involved in using science processes. This implies that the extent to which young learners can conduct scientific enquiries can only be assessed when they are engaged in enquiries familiar to them. As their experience grows, they become able to deploy their skills more intentionally to answer questions and solve problems in less familiar situations.

- *From unconscious to conscious action*

  Noticing something without observing it implies an unconscious act. In order to become aware of one's thinking and reasoning processes, it is necessary to deliberately apply ways of thinking to unfamiliar problems. This is referred to as the meta-cognitive dimension. Recent studies have shown that young children are capable of meta-cognitive thinking, and should be provided opportunities to advance these process skills (Harlen 2000:32).

It is important that teachers are aware of the dimensions of progression and the possibilities of progress in each science process skill: these will make their expectations of learners at each level developmentally appropriate, and also enhance their ability to foster the acquisition of process skills.

In the Natural Science Learning Area, the Assessment Standards for Grade R-3 provide a common national framework for assessing learners' progress. Progression across the grades are indicated in Chapter 4 (see par. 4.6.2.2).

3.5.4 Building attitudes that promote effective learning in science

As discussed in Chapter 2 (see par. 2.5.3.3), effective science learning is impossible without the attitudes that promote effective learning in science. In science, negative attitudes are often singled out as one of the main reasons for failure in science. When attitudes are negative, a vicious circle is created. In this section, the direction of progress in developing attitudes will be briefly mentioned.

Attitudes influence behaviour. Learners who feel that they can succeed are more likely to be successful, while those who anticipate failure, are less likely to be successful. Attitudes not only affect what is learned, but they also affect the effort that is put into the tasks given. The formation of attitudes are influenced by many different factors, for instance, maturation, social interaction, parents and other adults. Certain common trends can nevertheless be identified.

Harlen (2000:45-46) identified two dimensions of change that are particularly relevant to science attitudes:

- *From self-orientation to orientation to others*

  Orientation to the self implies looking at things from a personal point of view and focusing on one's own experience and ideas, with little interest to consider the input from others. In science, many activities are collaborative and ideas are constructed in interactions with peers. Moving towards orientation to others, being able to share with peers and being open to their ideas, are therefore an important aim in learning science.

- *From external motivation to internal motivation*

  The motivation to learn science needs to come from somewhere. Learners who are motivated by outside factors (gaining the approval of others or external rewards), lack the willingness to undertake tasks, to persevere and to complete tasks. Learners should be encouraged to take responsibility for their learning, and to move control from an external source to within themselves. This is particularly important in science, because the development of scientific ideas depends on a desire to understand and to persist until that particular satisfaction is gained which is typical to self-motivated learners.

Teachers need to be aware of progression in the development of attitudes. This will not only guide teachers in appropriate expectations of behaviour at each level, but also assist them in setting appropriate goals in terms of these expectations.

The achievement of scientific literacy depends on the acquisition of scientific knowledge and scientific process skills, but also on the values and attitudes pertinent to effective science learning. The acquisition of these aspects were discussed in the previous section. In the following section, the ways in which children acquire knowledge through appropriate learning experiences are explored.

3.5.5 The acquisition of knowledge through appropriate learning experiences

Carin and Bass (2001:74-76) suggest three main ways in which people learn about the world:

- *Discovered knowledge*

  As young children are natural scientists, they are actively involved in making sense of and building theories about the world. They find things out for themselves, or *discover* knowledge by engaging in experimentation and problem solving. In the process of discovery, they explore the world, observe its properties, actions and changes, and mentally represent the new information in a variety of ways (Carin and Bass 2001:74-76). Children need a strong foundation for constructing *physical knowledge*, that is, knowledge gained from sensory experiences about physical objects, to understand their behaviour as a result of their properties and attributes. Physical knowledge lays the foundation for later, more abstract thought (Frost 1997:15).

- *Knowledge acquired from others*

  Qualter (1996:37) views learning as a social activity within a social context. Considerable knowledge is acquired outside formal education: through hobbies, medical visits, by reading instructions on technical goods, by being aware that certain things are possible (e.g. cellular networks across the world, water and electricity in homes); by watching TV, reading books and magazines, through interaction with construction materials; from science fiction, and so forth (Frost 1997:16).

  Formal education provides other contexts. Activities are planned with learning as outcome. Science content that has been arranged by scientists and teachers into domains of terms, facts, concepts, and rules is presented in science classes through lectures, discussions, and so on. Research shows that socially transmitted knowledge is useful to learners. They are able to recall such knowledge and relate it to the initial lesson, or use it to carry out specific procedures. Socially transmitted knowledge provides them with various terms and categories for representing and expressing their discovered knowledge (Frost 1997:16; Carin and Bass 2001:74-75).

- *Personally constructed knowledge*

  Discovered and acquired knowledge must first be transformed into personal, constructed knowledge before it becomes meaningful. Meaningful knowledge is knowledge that has been personally organised through classification and rational thinking. New discoveries must be connected to prior knowledge in order to make sense for the child. The process requires teacher guidance and learner insight. Acquired or socially transmitted knowledge must also first be connected to children's own concrete experiences, and utilised in attempts to make sense of the world. Although the learners themselves play the leading role in this knowledge construction process, teachers have to actively assist them in transferring their concrete discoveries to more abstract ways of knowing the world, and building connections between new knowledge and prior experiences, other science topics and other learning areas (Carin and Bass 2001:75,76).

To summarise, teachers must be aware that learners need to *discover* a lot of physical knowledge, *acquire* significant knowledge from verbal and written sources and need assistance in *constructing* new knowledge that help them make personal sense of objects and phenomena in their environment (Carin and Bass 2001:78).

In order to understand how young learners construct knowledge, teachers need to know the children they work with. Children's learning needs must be considered and assimilated into a teacher's perspective on learning and teaching. In the following section, some characteristics of Foundation Phase learners that influence their learning of science, are explored.

3.5.6 Learning characteristics of Foundation Phase learners

Children in this age group are enthusiastic explorers. While investigating, they develop important science processes and concepts. They begin to refine their enquiry skills, identify changes in observed events, understand relationships among objects and events, and they start to use abstract symbols such as numbers and written words with understanding. For all of these, however, they still need hands-on exploration, tied to concrete experiences. At this age, they are enterprising and enjoy long-term projects, they are fond of building and collecting things, playing games with rules, learning systems of rules and making predictions. Peers are becoming increasingly important, so that working in small groups should be a basic instructional strategy (DoE (b) 2002:23).

The RNCS (DoE (b) 2002:23) describes the Foundation Phase learner along the following lines. Physical, emotional and intellectual development happens in spurts and not necessarily in any fixed way. Consequently, one developmental aspect may be well in advance of another aspect. Foundation Phase learners come to school with an eagerness to learn. They are able to use and understand their home language and solve mathematical-type problems (match, share). They demonstrate their understanding (by means of counters or drawings) before they are able to demonstrate their reasoning. They bring into the learning environment their own experiences, interests, strengths, and barriers. They know much less about the everyday world than adults realise.

All learners need to be recognised and accepted, and their families and cultures acknowledged and accepted. They thrive in a safe, structured environment. They feel intimidated by an unpleasant atmosphere, which prevents them from learning effectively. They do not respond well to tests and examinations. They need enough time to complete tasks and become nervous when hurried. They cannot concentrate for too long and are easily distracted. They find it difficult to be passive listeners and need to be actively involved in solving problems, constructing objects, measuring, comparing, and reasoning. They need to explain their actions and thinking at their own current level. Tasks should fit their abilities: not too difficult nor too simple. These learners are still egocentric and view things and situations from their very subjective perspective. Even when provided with set criteria, they are not yet capable of objectivity, and are very dependent on the approval of their peers.

Victor and Kellough (2000:40-43) provide a list of general characteristics that apply to Foundation Phase learners across the board, regardless of individual genetic or cultural differences:

- *Egocentric*

  Learners in this age group are egocentric and view everything as important insofar as it relates to themselves. Egocentricity is natural and explainable - children find themselves in a wonderful yet strange world, filled with phenomena that affect them personally in many ways. They try to interpret the phenomena according to how those phenomena affect them. They use everything they learn to help them adjust to the world in which they live. Foundation Phase learners are mostly interested in their own viewpoint on any matter - objects and events are described in personal terms and not by reference to how they might appear to other people. What the learner knows corresponds with what is seen and felt. Egocentricity decreases with age and maturity. Teachers should assist children to help overcome their egocentricity by developing learners' listening skills. When they learn to listen to, and to reflect on their peers' viewpoint, they learn understanding and empathy (Victor and Kellough 2000:40).

- *Curious*

  The natural sense of curiosity of learners in this phase leads to their exploration of the wonderful and exciting world by observing and manipulating objects and materials in the environment. To teach effectively, teachers should take advantage of this natural curiosity and try to sustain and keep it alive throughout their school years.

- *Interpretive*

  Learners in this phase are constantly trying to make sense of their experiences and interpreting their environment. They do this by referring to a body of related information from past experiences and knowledge stored in their long-term memory. This is a constant process of revising interpretations as they mature in their ability to understand and think abstractly (Victor and Kellough 2000:41).

- *Persistent*

Young learners have the desire to achieve their objectives and will spend time and effort at activities that are important and interesting to them. With their persistence comes a feeling of personal satisfaction and a sense of accomplishment. Teachers need to take advantage of this persistence and desire to achieve. Their persistence also causes them to be naturally resistant to changes to their interpretations. Teachers have to take this into consideration when misconceptions have to be altered through corrective instruction (Victor and Kellough 2000:41-42).

- *Adventurous*

They are adventurous and inquisitive, and love to explore, touch and feel objects. They are natural questioners who continually ask: what/why/how/what will happen if-questions. Teachers should provide a variety of hands-on learning experiences, and build on the inquiring and questioning nature of the learners.

- *Energetic*

According to pediatric neurologist Dr. Denckla, the brain's frontal lobe, the part that applies the brakes to children's natural energy and curiosity, is still maturing in 6-9 year old children. "Boredom tolerance", as she calls it, develops over time as the frontal lobe develops (Martin *et al.* 1994:32) . Most young learners cannot sit still for extended periods of time. They rather *do* than *listen*. Even while listening, they move their bodies restlessly. This does have an effect on their attention span. Teachers have to provide for kinaesthetic learning by offering a variety of activities that make provision for active involvement (Victor and Kellough 2000:42).

- *Social beings*

Young learners like to be with and be accepted by their peers; they measure and judge themselves in relation to others. Through social interaction, learners develop a satisfactory self-concept and tend to do better in school. Social development, in fact, is a prerequisite for academic success. Learners love to work together in planning and carrying out their activities. Ample opportunities for developing self-esteem and relationships between learners should be provided through group activities, science projects, cooperative learning and peer tutoring.

- *Various Psychological Needs*

  It is important to take into consideration the various needs of young learners that have to be fulfilled (Maslow). Teachers ought to be alert to any learner whose basic psychological needs are left satisfied; such a learner's classroom behaviour and learning will be affected adversely. A hungry, abused or insecure child may show signs of aggression, disruptive and antisocial behaviour. It is the teacher's responsibility to provide a classroom atmosphere where all learners feel welcome, respected, and wanted (Victor and Kellough 2000:43).

The first part of Chapter 3 dealt with issues relating to *learning* and the construction of meaningful understanding in science. In the following part of the chapter, attention moves to the *teaching* of science, in particular, different teaching methodologies that can be used in Natural Science education.

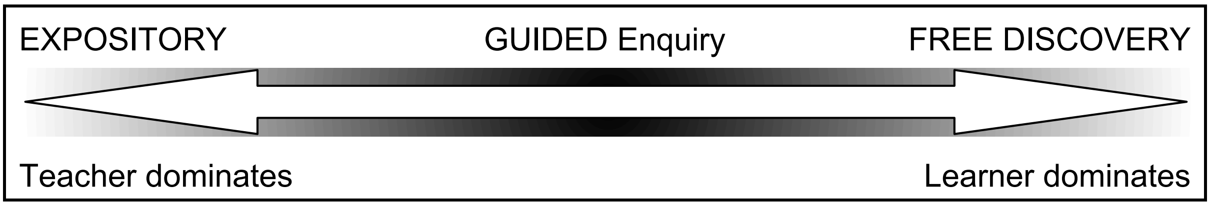
3.6 METHODOLOGIES OF TEACHING

Explicit knowledge of how the brain works, together with data clearly supporting the fact that learners construct knowledge for themselves, should have an effect on the choice of the teaching method. The teacher should consider ways in which learners will develop critical and creative thinking skills, but also develop the ability of children to engage in meta-cognition. Teaching in an integrated curriculum (see discussion on the integrated curriculum, par. 4.2.3) also places specific demands on the role of the teacher. The teacher takes the role as facilitator and mentor, and not as a purveyor of knowledge. She acts as source of support through assistance and conferencing with learners while they work to accomplish projects, investigate themes and solve problems. She also needs to present information specific to the needs of the children in her class. In this way, learners are provided the opportunity to learn through authentic experience rather than through lessons pre-planned by the teacher and divorced from context. Learners are therefore placed in the active role as inquisitor rather than passive recipient of information (Wolfinger and Stockard 1997:285,255).

Lowery (1998:29) finds it surprising that, in spite of this knowledge, some teachers see no need to change from overusing passive-learner instructional methods (e.g. show-and-tell) to using more thoughtful methods that enable learners to construct meaning for themselves through exploring relationships and webbing those explorations to their prior knowledge. It will therefore be important for teachers to keep up with new developments on how children learn and ways in which science is taught most effectively.

There are many different teaching methodologies described in literature. Experienced, competent teachers develop a repertoire of methodologies. There is no single method that will meet the needs of all learners in the classroom, but teachers should select the approach most suitable to the activity to be presented and to the learners in their class (Martin 2001:198). Teaching methodologies can be arranged on the basis of the proportional amounts of teacher and learner contribution to the learning situation. Martin (2003:206) provides an *expository-discovery continuum* that portrays the degree to which the teacher on the one side and the learner on the other side dominates the learning situation (see DIAGRAM 3 below):

DIAGRAM 3: EXPOSITORY-DISCOVERY-CONTINUUM



First, a brief overview of the ideas behind expository, discovery and enquiry methodologies is provided after which a few different teaching methodologies or approaches, suitable for the effective facilitation of Natural Science learning are investigated.

3.6.1 Expository methodologies

In the expository methodologies, also referred to as *traditional teaching*, the teacher dominates the learning situation by presenting material to the learners through lecturing, explaining, reading books, videos, science demonstrations, workbooks and other teacher-focused activities. The learning is teacher-centred and the learners are required to pay attention, absorb and learn whatever the teacher presents (Martin 2003:207; Searson and Dunn 2001:25).

3.6.2 Discovery learning

Discovery learning was a deliberate move away form the philosophy that children are passive recipients of knowledge through the traditional styles of expository teaching or the so-called step-by-step, "cookbook" approaches to learning (Fleer and Hardy 2001:150, Colburn 2004:64). Discovery learning is a concept advocated by Jerome Bruner (see par. 3.3.5). Bruner believed that discovery learning can only take place if the teacher and learner work together in a cooperative mode. This type of teaching is called "hypothetical teaching" and is differentiated from "expository teaching". Discovery learning in the classroom engages the learner in science activities designed to assist them in assimilating new information, concepts and principles. The aim of this approach is to teach students to "think like scientists through enquiry and active participation in the lesson". While the approach nowadays has a negative connotation (one of the reasons being the fact that children discover science, but do not find out the reason behind their discovery), it was based on the simple and worthy idea that "the ideas we tend to retain are those we create for ourselves" (Colburn 2004:64; Szesze 2001).

3.6.3 Enquiry-base approaches

The essence of enquiry can be traced back to John Dewey who proposed that enquiry is the "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (see par. 3.3.1). Enquiry-based instruction can therefore be regarded as a teaching practice that encourages learners to learn inductively with the help of real-world exemplars. This approach has a firmly established place in pedagogical tradition. For centuries, educators and theorists have championed learning through concrete experiences and observation rather than rote memorisation (De Boer, 1991 in Colburn 2004:63). In recent times, this concept is referred to through a variety of terms, such as learner-centred or constructivist learning (Colburn 2004:63).

3.6.3.1 Guided enquiry methodology

Guided enquiry combines the teacher focus of the expository methodology with the child focus of the free-discovery methodology. Guided enquiry methodology involves *learning by doing*. The teacher serves as facilitator, resource person and co-enquirer to guide learners in their efforts. She selects the topic to be investigated, introduces the activity and outlines the basic procedures and structures for the investigation.

The learners carry out the planned activities and then extend on their own to investigate the topic in accordance with their interests and abilities (Martin 2003:211).

3.6.3.2 Process-oriented guided enquiry

Guided enquiry uses an enquiry approach, based on constructivist principles, in which science content is used as the vehicle for mastery of the *processes of science*. In the process-oriented approach, learners investigate phenomena the way scientists do - this methodology can thus appropriately be termed the *process-oriented enquiry methodology*. Learners apply the processes of science in an enquiry format to investigate questions, situations and other scientific phenomena (Martin 2003:213; Martin 2001:209).

3.6.4 Enquiry versus discovery

There is often confusion about exactly what enquiry teaching is and how it differs from discovery learning. It is therefore justified to clarify the descriptions of these two important tools for the teaching and learning of science. A major reason why enquiry and discovery are sometimes confused is that in both, learners are engaged in *problem solving* (Victor and Kellough 2000:80). Problem solving is described as "the ability to define or describe a problem, determine the desired outcome, select possible solutions, choose strategies, test trial solutions, evaluate outcomes, and revise these steps where necessary" (Victor and Kellough 2000:80). Problem solving is often posed by some as a *method of enquiry*. Victor and Kellough, however, regard problem solving not a *teaching strategy*, but a *tool for scientific enquiry* (2000:80). They describe problem-solving as a higher-order behaviour that facilitates learning. When teaching science, teachers can and should provide opportunities for learners to identify and tentatively solve problems. Experiences in enquiry and discovery represent the processes for those opportunities. With the processes involved in both these approaches, teachers may help learners to develop the skills necessary for effective problem solving.

The difference between enquiry and discovery can be seen in the amount of decision-making responsibility given to learners. Victor and Kellough (2000:81) provides a table that demonstrates *who* identifies the problem and *the decisions* made *by the learners.*

TABLE 6: ENQUIRY VERSUS DISCOVERY

	LEVEL 1: Guided Enquiry/ Discovery	**LEVEL II: Beginning of True Enquiry**	**LEVEL III True Enquiry**
Problem identified by:	teacher or textbook	teacher or textbook	learner
Process of solving decided by:	teacher or textbook	learner	learner
Identification of tentative solution to problem resolved by:	learner	learner	learner

- *Level I*: Guided Enquiry or Discovery

Both the problem and the process of resolving it is defined *for* the learner. The learner then works through the process to "discover" its inevitable resolution. The learners are carefully guided through the investigation to the predictable "discovery". This level is highly manageable and the learning outcome is predictable - therefore probably best for teaching basic concepts and principles. In this level, problem solving and "sciencing" is wrongly viewed as a linear process.

- *Level II*: Beginning of True Enquiry

Real-world problem solving is a cyclic rather than linear process, therefore, true enquiry is cyclic, rather than linear. Learners, under the guidance of the teacher, decide and design processes for their enquiry. Teachers emphasise the tentative nature of conclusions. The activities are therefore more like real-life problem solving in which decisions are always subject to revision if new data so prescribe.

- *Level III:* True enquiry

Learners recognise and identify the problem, decide the process and reach the conclusion (Victor and Kellough 2000:81) .

In the following section, a variety of methods are presented. The first two methods have their origin in the expository approach. Following the expository methods, is a discussion of the free discovery method. Thereafter, a selection of enquiry-based methods will be provided and in the final instance, the learning style teaching approach is presented.

3.7 A PRESENTATION OF SUITABLE METHODS FOR TEACHING NATURAL SCIENCE

For most Foundation Phase learners, learning by sitting and listening is difficult. They learn best when physically and intellectually active; through hands-on, tactile and kinesthetic experiences; by touching, feeling, moving and talking about what they are learning. Careful selection of instructional strategies are therefore necessary. As was seen previously, two distinct approaches, namely teacher-centred (delivering information to learners) and learner-centred approaches (providing learners with access to information) can be identified.

Following is a presentation of a variety of methodologies and approaches, ranging between traditional expository methodologies (teacher-centred), enquiry-based and free-discovery methodologies, suitable for Natural Science teaching in the Foundation Phase.

The same sequence will not be followed at each method, but depending on the method under discussion, a brief overview, the ideas behind the method, a list of advantages and/or disadvantages, or the steps involved will be provided.

3.7.1 The transmission approach

The transmission approach as referred to by Fleer and Hardy (2001:133-134), is a form of *expository* teaching. The transmission approach to teaching Natural Science places heavy emphasis on the idea of *science as a body of knowledge* that must be taught and learnt. Teachers using this approach must ensure that science knowledge and language used are at an appropriate level for the learners in the group.Content should be carefully selected and modified. The most important learning outcome in this approach is the learning of scientific knowledge - facts, concepts, theories, laws - rather than learning the practical skills in *doing* science.

While expository teaching is necessary and useful in certain circumstances, it is difficult if not impossible for the teacher to be sure if the learners are engaged and if they have internalised that which was intended (Martin 2001:199). The teacher using this approach is also unlikely to find out the children's prior knowledge and misconceptions before teaching a topic. It is usually assumed that their pre-existing knowledge is deficient or almost non-existing (Fleer and Hardy 2001:133-134).

Eggen and Kauchak (1994:411) list several serious disadvantages of this approach:

- Uncertainty of the degree of mental involvement of the children.
- Inability to tailor lessons to meet the individual needs of *each* child.
- Inability to get all children to follow the flow of the lesson at the same pace.
- Uncertain relevance of the material to *each* child.
- Encouragement of learners to be passive learners.
- Fostering of overdependence on the teacher as source of knowledge.
- Reduced encouragement of children to think for themselves.
- Reduced encouragement of children to develop and test their own constructions of their own conceptualizations.

Although there are many potential negative outcomes from using this approach, it can be justified in the following situations:

- Providing access to unfamiliar topics. Particular topics such as *dinosaurs* are difficult to teach without books, pictures and models. Effort should however be made to involve learners actively with real life exemplars, by for instance, observing living dinosaur relatives (e.g. lizards/birds).

- Providing a knowledge base at the start of a topic from which learners can draw to make sense of their findings.

- Helping children to make connections in their understanding or to make connections between new and existing knowledge. In planning a science topic, the teacher also might consider a transmission element appropriate *to follow* another approach (such as discovery).

- Developing the use of scientific language. Learning scientific terminology might be incorporated to enhance the learning process.

- Children transmitting their knowledge to peers. After science activities, learners are often required to share their findings or conclusions with others and are therefore provided the opportunity to use their new scientific understandings (Fleer and Hardy 2001:137-139).

3.7.2 Ausubel's instructional model

The Ausubelian model is often associated with *expository learning* (see discussion on Ausubel, par. 3.3.5). Ausubel claimed that, for meaningful, lasting learning to occur, new knowledge must be linked to previously taught information in the class, so that learners can make the proper connection (Martin 2003:214, 215).

The following are instructional principles of the Ausubelian model:

- The most general ideas of a learning area should be presented first and then progressively differentiated in terms of detail and specifics.
- Instructional materials should attempt to integrate new materials with previously presented information through comparisons and cross-referencing of new and old ideas (Telkamp:online).

Three important criteria for meaningful learning in the Ausubelian model should be mentioned:

(1) The learner must have relevant prior learning.
(2) The learner must manifest the meaningful learning set.
(3) The learner must be given meaningful learning tasks (Marek and Cavallo 1997:98).

Three stages were specified by Ausubel to ensure the proper connections: advanced organiser, progressive differentiation and integrative reconciliation. Regardless of the orientation of the methodology, Martin (2003:217) maintains that any effective lesson should have an advanced organiser, follow a logical sequence, have appropriate content, and encourage learners to make meaningful connections to prior information.

Stage 1: Advanced organiser

Learning is facilitated when learners are supplied with an appropriate frame of reference so that new information can be linked to information they already possess. This frame is referred to by Ausubel as the *advanced organiser*. The teacher must provide an advanced organiser before starting any new lesson or activity. It sets the stage. By providing an overview, showing learners what to expect and summarising all aspects of the lesson in advance, focus or direction is provided and the learners' interest captured.

For a new unit, an advanced organiser might include an interest-provoking activity or discrepant event to start off with, followed by a general discussion of what the lesson entails and what learners will be required to do. For a lesson in an ongoing unit, an advanced organiser would remind learners of previous lessons and would show how the new lesson is connected to earlier information.

Stage 2: Progressive differentiation

After setting the stage for the lesson in the advanced organiser, each item of information or skill must be isolated so that it can be connected to previously learned information. Effective progressive differentiation relies on the lesson to move in a logical manner and to flow smoothly, making sure that all concepts needed for understanding are included. Materials should be progressively differentiated. The use of concept mapping is of great assistance in ensuring proper progressive differentiation for lessons.

Stage 3: Integrative reconciliation

After setting the stage and progressing from the most general to the most specific in a way that encourages learners to make meaningful connections to prior information, the teacher must now ensure that the learners have constructed the material correctly. The teacher helps each learner to reconcile the new material with previously taught material and with the learner's own experiential bank - this is called *integrative reconciliation*. During this stage, the teacher can identify inconsistencies between what the learners are thinking and the correctness of the material, and help them reconcile these inconsistencies (Martin 2003:215-217).

3.7.3 Free discovery method

The free discovery methodology follows a learner-centred approach where the learners make the decisions about *what* is important for them to learn and *how* they are going to learn it. Discovery learning in science implies that children can easily find out the scientific principles or understandings by interacting with materials. The teacher's role is de-emphasised as she acts more as a facilitator and organiser of resources (Fleer and Hardy 2001:158; Martin 2001:200).

Free discovery methodologies are prevalent in Montessori schools where learners are offered opportunities to freely select topics and activities that are of interest to them. Their learning is facilitated through the discovery approach, tailored and paced to suit the needs of each individual child. In the Reggio Emilia programme, a free discovery approach (based on constructivist principles), is also followed where children are encouraged to create their own meanings while they explore complex situations (Martin 2001:200).

Various contexts for discovery learning can be found in the formal education system today, such as:

- the nature/science table where learners can freely explore materials placed out by the teacher and
- modified discovery learning where the teacher sets the problem, but allows children to suggest ways they might go about solving it (Fleer and Hardy 2001:150-151).

The free discovery methodology is valuable as it fosters learner's construction of their own ideas, and places responsibility for learning on the child, thereby ensuring ownership of the knowledge they constructed. This method presupposes however that learners are able and ready to take responsibility for their learning, including the ability to select suitable topics, to develop meaningful learning experiences, and to work independently. Young learners, however, may have difficulty in assuming responsibility for their own learning. Another concern about this approach is the emphasis on discovering what the materials do, and not on finding out why (Fleer and Hardy 2001:159).

Martin (2001:201; 2003:211) mentions more *disadvantages* of free discovery methods:

- Lack of structure.
- Frustration by children over reduced dependence on the teacher.
- Decreased teacher control over the content and the curriculum.
- Increased requirement for equipment and materials.
- Possible increase of behaviour management problems.
- Increased organizational and other managerial requirements.

Although research indicates that learners who were taught through the discovery approach *liked* science more and were *better at doing* science than their peers taught with other curricula, critics contend that having learners discover all major science concepts is unrealistic and counterproductive. Discovery-based curricula are also criticised as being cumbersome and placing unrealistic demands on especially generalist primary teachers to understand an extremely wide range of science content (Colburn 2004:65).

3.7.4 Teaching using the Learning Cycle

In the 1960's, new hands-on science approaches which led learners through a series of activities to master the processes of science, replaced the former content-oriented programmes. The now well-known “learning cycle” was designed to guide teachers in facilitating children’s inquiries (Martin 2003:20). The learning cycle is not a method. It is, however, a teaching procedure which, by design, allow for many methods of teaching, for example, questioning strategies, demonstrations and group work (Marek and Cavallo 1997:128).

The *5E’s Learning Cycle* was developed as a method of structuring science activities that is based upon constructivist learning theory, research-based best practices in science pedagogy and cognitive psychology. This method is described as a recursive cycle of distinctive cognitive stages of learning that include:

engage → explore → explain → extend → and evaluate.

Science activities presented through this method often takes several days or weeks to complete (Szesze 2001).

A brief explanation of the 5E’s Learning Cycle method according to Szesze (2001) follows:

- *Engage*

Through this introductional phase, the learners’ interest or curiosity in the learning to follow is hooked through a demonstration, discussion, reading or other activity. In this phase their prior knowledge is also uncovered.

- *Explore*

Learners are provided with the opportunity to have experiences with the concepts and ideas of the lesson as they observe, question and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas. Learners are encouraged to work together without direct instruction from the teacher.

- *Explain*

Learners are encouraged to explain concepts and definitions in their own words, to justify and to clarify their ideas. Formal definitions, explanations and labels are provided through discussions and chalk talks, that are didactic in nature.

- *Extend*

In this stage, learners are allowed to apply their new labels, definitions, explanations and skills in new, but familiar situations. This often involves experimental enquiry, investigative projects, problem solving, decision making and laboratory work where learners develop and complete their own well-designed investigation.

- *Evaluate*

Both learning and teaching are assessed using a variety of informal and formal assessment strategies. Teachers observe learners as they apply new concepts and skills to assess their knowledge and skills and to find evidence that learners have changed their thinking or behaviour. Opportunities for learners to assess their own learning, as well as group-process skills, are also provided.

Although the 5E's were described in a linear order, it is helpful to view the 5E's Learning Cycle as recursive and looping back on itself. It is often appropriate to loop back into the cycle before learners have the full ability to go forward (Szesze 2001).

3.7.5 The High/Scope approach

It seems as if many of the ideas from the High/Scope approach to science education were woven into the NSLA (see par. 4.6.2.2, *Assessment Standards*: Plan; Do; Review). It is therefore justified to explore the ideas and approaches of the High/Scope Curriculum further. David Weikart and Constance Kamii collaborated in the early 1960's with an intervention programme, the Perry Preschool Project. Kamii studied under Piaget from 1966 and Weikart continued to work with the project, revised and extended the curriculum and established the High/Scope Educational Research Foundation. His High/Scope model is an eclectic approach based on Piaget's theory of cognitive development, the child development tradition and ideas that Weikart felt were missing from the Piagetian theory. This programme was designed to improve disadvantaged children's chances for academic achievement.

While specific times are devoted to science activities in the High/Scope Curriculum, many opportunities to integrate science with other learning areas such as languages, mathematics, social studies and the arts are also possible (High/Scope:online). In the South African Curriculum however, the NSLA is only integrated into the Life Orientation, Mathematics and Languages Learning Areas (see par 4.8).

The aim of the High/Scope approach to science is to bring an active, hands-on, minds-on process to science learning. Science in the High/Scope approach is viewed as a *process of enquiry*. In keeping with the constructivist and hands-on aims of the High/Scope Curriculum, learners are encouraged to be actively involved in an exploratory process that involves problem solving activities and the discovery of patterns of regularity and causal mechanisms. In this approach, the science process skills - that define the actions learners can and do perform - play a central role. The selection of content from the concept domains of science (in which actions defined by the process skills lead to authentic scientific knowledge and understanding) is viewed as equally important (High/Scope:online).

3.7.5.1 Science Workshops in the High/Scope approach

Science activities can be organised by the teacher and carried out by small, teacher-directed, semi-independent or - on occasion - large groups. In science workshops, learners are involved in hands-on science experiences such as growing and observing seeds, testing materials, analysing mixtures, making and comparing measurements and preparing reports/projects to show their work. Small groups of learners can rotate through three to four workshop activities. When science activities are juxtaposed with mathematics or language activities, opportunities for learning area integration are especially strong (High/Scope:online).

3.7.5.2 Science During Plan-Do-Review in the High/Scope approach

Weikart maintained that children are active learners and developed the curriculum so that children could use the cycle of *plan-do-review* with activities of their choice. The teacher meets with the learners to find out what they have *planned* for the activity and after the conference, each learner begins with the *doing* phase (or in other words, carrying out the plan). With regular intervals, the teacher *reviews* the plan and the child's learning (Brandscombe, Castle, Dorsey, Surbeck and Taylor 2003:300). Science materials and activities introduced to learners during science workshops, are likely to stimulate their interest. Plan-do-review periods provide opportunities for learners to continue, or expand on their interests, or to initiate science activities based on their interests. Learners may then plan to work with science materials in the science centre, or to work on a project in some area in the classroom (High/Scope:online).

3.7.6 Grouping and cooperative learning

In an outcomes-based and integrated curriculum, grouping becomes important. Many of the methodologies used for Natural Science teaching use grouping or cooperative learning as part of the process. A brief discussion of grouping and cooperative learning possibilities therefore seems justified.

There are different ways in which learners may be grouped:

- *heterogeneously* - different learners bring different interests and skills to the group;
- *homogeneously* - similar interests can be used to focus on a concept; or
- *cooperative learning groups (CLG)* with more formalised structures (Wolfinger and Stockard 1997:285).

The theory of cooperative learning has evolved from the work of Lev Vygotsky and other social constructivist theorists (see par. 3.3.3). It is based on the premise that, when small groups of learners of mixed backgrounds and capabilities work together to achieve a goal or complete a task, the members of that group increase their friendship and respect for one another. In some types of cooperative learning, the group is required to work together on a single task, while in other cases, members of the group work individually and then add together the results of the work when they are finished. In cooperative learning, the academic performance of learners is raised, because they help and support each other and learn from one another. Because CLG is a heterogeneous group (mixed according to one or more criteria such as ability or skill level, ethnicity, learning style, learning capacity, gender, language proficiency), cooperative learning is ideal for inclusive settings as learners with lower abilities as well as learners from different ethnic groups are given the opportunity to succeed in a cooperative situation. Learners learn about and appreciate each other's strengths and begin to develop friendships (Victor and Kellough 2000:97; Wolfinger and Stockard 1997:285).

CLG can be used for problem solving, investigations, opinion surveys, experiments, project work or almost any other instructional purpose. There are several techniques for cooperative learning, for example, STAD (Student Teams-Achievement Divisions), Jigsaw and Group Investigations - these will not be discussed here. The primary purpose of each is for the group to learn. *Group achievement* in cooperative learning is dependent upon the *learning of individuals* within the group. Rather than competing for rewards for achievement individually, members of the group cooperate by helping one another to learn, so that the group as a whole will be rewarded. Individual roles should be assigned, understood and performed within the group - no group member should be allowed to ride on the backs of the other members of the group. Cooperative learning requires many skills such as interpersonal as well as cooperative skills - and these must often be taught. Members are also sometimes required to learn the process of conflict resolution. As with any other type of instructional method, CLG should not be overused (Victor and Kellough 2000:97-90; Wolfinger and Stockard 1997:285).

Considerable challenges exist for the teacher using this approach. The teacher cannot simply tell learners to divide into groups and call it cooperative learning. Advanced planning and effective management is a requirement for this strategy to work. Learners should be trained in and have acquired the basic skills in interaction and group processing, and should also realise that individual achievement rests with that of their group. Learners must be assigned a responsible role within the group, and groups must be continually monitored by the teacher for possible breakdown of the process within the group, so that the teacher can appropriately intervene and help the group to get back on track (Victor and Kellough 2000:99).

3.7.7 The process skills approach

The NSLA focuses on a process skills approach to teaching science. This process-oriented guided enquiry approach (see par. 3.6.3.2) is concerned with the *process of science* or, in other words, "What do scientists do?" The science process skills approach to teaching science advocates a particular view of science. It supports the view that science is about discovering the truth. When focusing on process skills, great value is placed on the processes of science and not necessarily on the content (Fleer and Hardy 2001:122). Teachers need to be aware of the assumptions implicit in the approach they adopt in the classroom. (The process skills were discussed extensively in paragraphs 2.5.3.2 and 4.6.3.)

Lessons taught in the process-oriented enquiry methodology require planning. Lessons following a constructivist approach require even more extensive planning than expository lessons, as teachers must plan for as-yet unknown questions, contingencies and enquiry directions that may emerge as learners develop their own personal constructions (Martin 2001:203).

In guided enquiry, learners begin at a common starting point, and then work to develop self-constructed understandings of common concepts. Although individual learners may take different paths, they all start and end at the same point. Following carefully structured lesson plans help keep the focus on the outcomes or destination, while at the same time enabling the teacher to follow the learners' thought processes and various enquiry routes. Martin provides components of planning process-oriented enquiry lessons that should be included in every process-oriented lesson (Martin 2003:218-220).

3.7.7.1 Components of process-oriented enquiry lessons

The following steps can be followed in the lesson plan format for the process skills approach:

- Target the age or grade level of the learners in the class (Grade R, 1,2, or 3).

- Formulate the specific scientific processes that will be addressed - one or more of the science processes that serve as the focus of the lesson (e.g. observe, compare).

- Write down the science topic that will be addressed. The topic will be used as vehicle through which the learners gain experience in the processes on which the lesson focuses (appropriate content may be taken from the core knowledge and concepts provided by the NSLA, e.g. “The atmosphere as a system”).

- Clearly state the objective (one or more). The objective is process-based and sets the direction for the lesson (e.g. “The learners will observe ...., communicate findings to each other”). The objective uses the scientific concept that was identified to serve as vehicle for exploring the process that is the focus of the lesson.

- Articulate the scientific information the learners should acquire. Clearly indicate what the learners need to discover - this helps provide focus to the lesson.

- Describe thoroughly the introductory activity and initial discussion. Details on how the lesson will be introduced, directions, special instructions for behaviour expectations and safety precautions, a cognitive disequilibrium that will be induced, and the like must be provided. The introductory activity sets the tone for the learners’ subsequent explorations.

- List the materials needed. All materials for the planned activity as well as possible extensions and variations, should be assembled beforehand.

- Describe activities fully. Details of what the learners will do to explore the concept, and the actions of the teacher to assist learners in their exploration, should be described in full.

- List typical discussion questions that can be used to guide learners and to stimulate their thinking toward their own valid constructions.

- Indicate how independent investigations will be fostered. Plan how learners will be encouraged to investigate the phenomenon on their own in the classroom and what learners might do to continue the investigation in greater depth, and to explore additional variations and related topics.

- Forecast expected conclusions which can be reached as a result of the investigations. If learners come to expected conclusions or unexpected valid conclusions, the lesson can be seen as successful.

- Apply to real life situations. Practical and life-based applications of the lesson are important. The investigation should relate to children’s life in some way. If an activity cannot be applied to the learners’ own lives, it lacks meaning.

3.7.7.2 Guidelines for using the process skills approach

Fleer and Hardy (2001:109) provide guidelines for teachers using a process skills approach to manage children's learning. This approach relies on the teacher to:

- find learning experiences that will develop the process skills;
- decide whether there will be groups or multiple tasks (the whole group doing the same thing/ small groups doing different tasks);
- organise enough materials for all children to manipulate the materials;
- think through safety and cleaning issues beforehand and have all the materials available and accessible;
- allow enough time for children to explore the materials;
- organise children into groups and set up the room before starting;
- allow recording and sharing time immediately after the hands-on activity;
- think through how to deal with groups finishing before others;
- allow enough time to clean up after the activity; and
- plan time and space into the lesson to observe individual learner's capabilities.

3.7.8 Project-Based Instruction (PBI)

Projects are not new in early childhood and elementary education. They have been used in progressively oriented educational programmes in the United States since the early 20th century (Dewey) and became a central feature of many British schools in the 1920s. A somewhat different form of the project approach was also used at Bank Street (USA) and Reggio Emilia (Northen Italy) where learner interests and abilities were integrated with the academic curriculum while promoting cognitive, linguistic, aesthetic and social-emotional development (Rainworth and Kugelmass 2003:50-51). The features that characterise project work reflect the constructivist principles which emerged from the work of Dewey, Piaget and Vygotsky (Rainworth and Kugelmass 2003:48). (Compare par. 3.3.1; 3.3.2 and 3.3.3).

Project-based instruction differs from other instructional methods in that projects are intentionally designed by teachers and learners to address specific learning objectives. *Instruction* is *based* on the activities taking place within the context of classroom *projects*. The objectives are derived from curriculum objectives or may include individualised learning objectives. In PBI, teachers intentionally facilitate activities designed to develop knowledge, skills and dispositions while reinforcing and applying children's existing cognitive, linguistic and social skills in new situations (Rainworth and Kugelmass 2003:48). A noted project expert, Prof. Sylvia Chard of the University of Alberta, defines a project as "an in-depth investigation of a real world topic worthy of children's attention and effort" (quoted by Curtis 2002:50). Projects are usually undertaken by a whole class working on sub-topics in small groups, or sometimes by a small group of children within a class. Occasionally, a project is undertaken by an individual child. The essential feature of a project is that it is an investigation - a piece of research. In this investigative process, children are involved in seeking answers to questions they have formulated themselves, in cooperation with their teacher or which arise as the investigation proceeds (Katz and Chard 2000 in Rainworth and Kugelmass 2003:48). Through projects, learner enquiry and research into a topic that is related to the curriculum or their interests are promoted (Rainworth and Kugelmass 2003:48).

The characteristics of project work are as follows:

- Projects are directed at studying one or more subject areas, themes or children's concerns.
- Activities are designed to promote cognitive, linguistic, and social-emotional development in learners.
- Learners are encouraged and supported in their use of multiple learning modalities and intelligences.
- Opportunities to apply acquired knowledge and skill in new situations are provided.
- Learners are actively involved with one another in designing, developing and assessing their work.
- Learning is demonstrated by a culminating product of performance (Rainworth and Kugelmass 2003:49).

Assumptions that underpin project-based learning include the following:

- All learners are capable of higher-level learning with in-depth study of a topic.
- Basic skills can be taught within the context of meaningful learning and critical thinking.
- Most learners learn best in a community of learners. They also learn peer-tutoring skills.
- All learners - from special education to gifted - are engaged in hands-on, project-based learning (Curtis 2002:51; Winebrenner: 1996:66).

For young learners, project-based learning is implemented through the project-approach, a three-phase structure for in-depth study of a topic that interests learners (Helm 2004:59). The three phases are (1) Beginning, (2) Investigation, and (3) Culmination. A flexible framework for project-based instruction is provided below (Curtis 2002:51; Helm 2004:61; Winebrenner 1996:66-67).

Phase 1: Beginning/getting started

The teacher selects a topic of study for the project. The topic will result from learners' interests, curriculum standards and availability of content from local contexts. The teacher discusses the topic to establish the learners' prior knowledge and guide them in formulating questions to be answered by their investigation.

Phase 2: Investigation/developing the project

The teacher provides resources, and suggests ways for learners to carry out a variety of investigations. She also arranges opportunities for field work and interviews with experts. Learners are encouraged to choose their learning style strength to effectively learn the suggested material. During this phase, new questions should be noted. Children should record and represent what they have learned.

Learners are also encouraged to prepare timelines showing the various parts of the projects, including the due date.

Phase 3: Culmination/concluding the project

The teacher arranges a culminating event for learners to make their presentations through which they share their findings and experiences with others. The teacher involves the learners purposefully in reviewing and evaluating the whole project and helps them decide how to display their results and select an appropriate method of expressing what they have learned. For projects that take a long time to complete, learners can give brief progress reports every two to three weeks.

Project work that captures learners' curiosity motivates them to learn academic skills such as decoding, getting meaning from text, writing words, creating diagrams and counting (Helm 2004:59). When learners are given the latitude to pursue topics that interest them by doing what scientists do, they go far beyond the minimum. They make connections among different areas of learning in their quest to find answers to open-ended questions. They also retain what they have learned, are able to apply their acquired learning to new situations and real-life problems, are absent less often and have fewer discipline problems. They get excited about learning (Curtis 2002:51).

This approach can generate many rewards for both teacher and learners. However, the following aspects provide a challenge for teachers using PBI:

- finding suitable topics that incorporate the required curriculum while allowing learners to follow their interests;
- in-depth investigations involved in projects often take longer than expected; classroom management of projects may be complicated, although many teachers found that learners' engagement in projects reduce disruptive behaviour;
- assessment provides a challenge as teachers find it difficult to design assessments that accurately measure learners' understanding;
- this approach generates more work for the teacher than the traditional textbook curriculum;
- teachers need to be ready and skilled to pursue learners who wants to take off in an unexpected direction to keep on track;
- teachers need to make sure that a learner covers a required state or local curriculum;
- teachers often have to admit that they do not have the answer and direct learners to outside resources;

- they must oversee learners working on a large quantity of different aspects of a theme and working at different paces and skills levels;
- they must come up with a grading system that reflects evidence of mastery in a product or portfolio (not a single test) (Curtis 2002:51).

3.7.9 The interactive teaching approach

A method that can be closely linked to the project method is the interactive teaching approach. Interactive teaching has become a widely known and widely adopted approach in Australia and New Zealand since 1990. It is currently considered by many science educators to be the most effective approach to teaching science (Fleer and Hardy 2001:167). There are many similarities between the project and the interactive approaches, but the interactive approach is the only approach that explicitly builds in processes focussing on achieving conceptual change in learners. This approach can be more appropriately called the *conceptual change teaching method*.

As with any approach, the teacher needs to be aware of the assumptions underpinning the approach she uses in class. The assumptions that underpin an interactive teaching approach will be discussed briefly.

The basis of the interactive teaching approach is the constructivist view of learning. The focus of interactive teaching is to achieve change in the ways learners make sense of their world. Interactive teaching assumes that children will come to class with their own understandings of their world and meanings for many words used in science (see par. 3.5.2.3). These ideas are likely to be noticeably different from the ideas of scientists. If children's ideas are ignored in teaching, they will remain unchanged, or changed in unexpected ways - their incorrect ideas may be reinforced. These assumptions about children's learning calls for a patient and planned teaching approach to achieve the change. A key assumption in the interactive approach is that there is interaction between children's initial ideas and those in their new experiences. Children actively attempt to make sense of these experiences by constructing meanings. Children do not only *assimilate* new concepts, but they also *modify, develop and change* their existing concepts. This view suggests that conceptual understanding and the ability to make sense of new situations are not directly related to *age*, but rather to their *experiences and ideas*. Construction of knowledge is not typically a solitary activity. The learner in the classroom is in a social setting and ideas are usually negotiated with the teacher and with other children.

For meaningful learning to occur, new knowledge has to connect with prior knowledge. Learners often fail to make this connection on their own. The role of the teacher is critical and complex. The teacher must intervene in the learning process by guiding learners to have significant control over their learning process. Through providing a supportive learning environment, learners are guided to generate their own helpful and relevant questions, and encouraged to investigate them (Fleer and Hardy 2001:177-178). The interactive approach presents science as multifaceted and emphasises science as a human construction accessible to all (every person regardless of race, gender, etc. construct meaning in science throughout their daily lives). It also lends itself to a vast range of topics that must be linked to children's experiences and interests (Fleer and Hardy 2001:177, 199).

The assumption that young learners are capable of taking control over their own learning is well justified. Research evidence exists that children prefer learning from their own questions, and value learning about other learners' questions, as this often challenges them to think about aspects of a topic they have not considered.

It is important that learners have knowledge of their own understanding and learning process. They should be taught to recognise these. This incorporates a *meta-cognitive* element (see the role of the teacher as change agent in par. 3.5.2.3). The need for this consciousness in learning science is important for the following reasons:

- Learners must recognise that the new information is related to what they already know.

- Then they have to link this information to two types of prior knowledge:
  (1) that which is consistent with scientific notions; or
  (2) that which is incompatible with scientific notions.

- The connection to the latter leads them to realise that their own ideas are not complete or satisfactory explanations, and that the scientific view is a more convincing and powerful alternative (Fleer and Hardy 2001:178-179).

3.7.9.1 The steps involved in the interactive method

Step 1: Preparation

In this approach, the teacher and learners work cooperatively to select a suitable topic to investigate and find background information.

Step 2: Before views

Learners are required to say or record what they already know about the topic and to draw a concept map and link it to ideas and knowledge about the topic without consulting resources about the topic. In this way, learners' prior knowledge is established.

Step 3: Exploratory activities

The learners are involved more fully in the topic. They observe real objects under different conditions. Through steps 2 and 3, learners discover their knowledge (or lack of knowledge) regarding the topic and write down the questions they have or the problems to be solved through investigation.

Step 4: Learners' questions

Learners are required to write out a list of questions for further investigation. They may choose to work independently or with a partner and aim to agree on three to four questions that can fairly easily be investigated. Questions that might be difficult to investigate (those that are too time-consuming, or need elaborate equipment) should be ruled out. Learners should also consider how they might find answers to their list of questions.

Step 5: Investigations

Teacher and learners select 2 or 3 questions per day to explore over three to four days. Learners develop a range of strategies and write them down. They should attempt to ensure that they use a number of strategies and not only rely on books or Internet sources. At least one of their strategies should involve their investigation with real objects. The investigations must then be planned in detail (individually or with a partner).

Learners are required to record their initial ideas about possible answers for each of the listed question. They should also record what they do to find answers. These recordings should be comprehensive and clearly structured.

Step 6: After views

In the final step, individual or group statements are compiled and compared with earlier statements. Learners return to their original concept map and drawing. They add their newly acquired ideas to the concept map in a different colour. They also draw a picture of their ideas alongside the initial picture and label the new picture with what they have learned about the object's features. They compare the pictures and think about how much they have learnt through their investigations. They are also required to consider the ways through which they have learnt what they now know.

Step 7: Reflection

During this stage, time is provided to establish what has been verified and what still needs to be sorted out. Learners may list new questions they would like to pursue.

Step 8: Preserve nature

In the case of live creatures, learners are required to return them to their natural habitat after completion and reporting of their investigations. In doing so, learners are taught to act responsibly as they work scientifically and not to disturb the environment unnecessarily (Fleer and Hardy 2001:171-174;176).

The interactive approach presents many challenges for the teacher, but can also generate many rewards. It can make an important contribution to the teaching of science. Elements of the approach can be used in constructing modified forms of the process skills, transmission and discovery approaches. Children are interested and committed when they are allowed to have substantial control over the learning process. The approach allows for individuality and caters for a wide range of abilities, background experiences, prior knowledge and interests. It caters for gifted and talented learners, for different cultures as well as different genders. Sensitive grouping of children will be an important consideration to ensure that all participate effectively in their investigations (Fleer and Hardy 2001:199).

3.7.10 The learning style teaching model

In all the methods discussed above, it became evident that learners are required to be actively involved in their own learning. All people however, learn more and retain it longer when they learn in ways comfortable to them. Learners display many different learning styles and potentialities and bring the heritage and prior knowledge of many different cultures to the classroom. It is therefore important for Foundation Phase teachers to be aware of each individual's preferred learning style. They should be able to identify learners' learning style preferences. Teachers must then design and deliver instruction that achieves maximum possible congruity with the learning styles, abilities, and cultural factors of the learners in their class (Martin 2003:240,277; Searson and Dunn 2001:22).

Furthermore, teachers worldwide are pressured to bring the best practices in science education and learning into their classrooms and to improve learner achievement in science. Science achievement can be increased by using the learning-style approach. The results of a study conducted with three third-grade learners, demonstrate the effectiveness of the learning-style teaching approach (Searson and Dunn 2001:22). Although the entire study cannot be presented here, the main features of the learning-style teaching model and the findings of the study will be discussed briefly.

What is a Learning Style? (see par. 3.4.2). Learning style is a "biologically and developmentally determined set of personal characteristics that make identical instruction effective for some students and ineffective for others" (Dunn and Dunn 1992 as quoted by Searson and Dunn 2001:22). The theory surrounding learning styles centres on the premise that each individual concentrates, processes and remembers new and difficult information in very different ways. In the model of Dunn and Dunn (1992), learning style is defined as "an individual's personal reactions to 21 elements when concentrating on new and difficult academic knowledge and skills". The 21 elements are grouped into five categories of stimuli, namely environmental, emotional, sociological, physiological, and psychological (Searson and Dunn 2001:22).

See TABLE 7 (Elements that have an influence on an individual's learning style).

TABLE 7

Category	**Elements that have an influence on an individual's learning style**
Environmental:	Sound, light, temperature, design. An individual's learning style is partly influenced by his/her preference regarding sound vs silence; bright vs soft lighting; warm vs cool; formal vs informal seating.
Emotional:	Motivation, persistence, responsibility and preference for structure vs choice.
Sociological:	Learn alone or with peers; work with a collegial or authoritative adult.
Physiological:	Perceptual strengths, e.g. auditory, visual, tactual, and kinesthetic skills; time of day energy levels; intake while concentrating; and mobility needs.
Psychological:	These elements describe the way in which individuals process information. *Analytic* learners focus on detail in a step-by-step manner - fact gradually build up to an understanding; they respond to printed words and numbers. *Global* learners need to understand how the learning content relates to them and their lives before they can focus on the facts; they respond better to illustrations and pictures.

(Searson and Dunn 2001:23).

The learning style model is based on the premise that:

- most individuals are able to learn;
- learners with diverse learning style strengths respond differently to instructional environments, resources and approaches;
- every individual has different strengths;
- individuals' instructional preferences can be measured reliably;
- style-responsive environments, resources and approaches have a positive influence on learner achievement, attitudes and behaviour;
- most teachers can use learning styles as a basis of their instruction;
- most learners can capitalise on their learning style strength when concentrating on new and difficult information (Searson and Dunn 2001:23).

For the study referred to by Searson and Dunn, *The Learning Style Inventory* (LSI) of Dunn, Dunn and Price (1996), was administered to identify learners' learning-style perceptual preferences. The instructional materials used for this group included hands-on and large-body resources (tactual and kinesthetic manipulatives). Learners were permitted to use their hands to find correct answers to science problems and the manipulatives helped them to learn factual information in a combined visual/tactual mode. The control group received traditional instruction that included readings from a textbook, discussions and answering of questions at the end of each lesson. The findings revealed that the learners who were taught tactually and kinesthetically achieved a significantly higher *simple recall science achievement* score as well as a significantly higher score on *higher-level cognitive science achievement* than the learners who were taught traditionally (Searson and Dunn 2001:24-26).

It seems as if the learning-style model can be a useful approach for Foundation Phase teachers who want to capitalise on learners' individual strengths to meet the standards of science education, and to increase scientific understanding and achievement.

3.7.11 Summary

No single teaching method is suitable for all purposes. It is recommended that different approaches be used at different times in different contexts and in attempting to achieve different learning outcomes (Fleer and Hardy 2001:195,197-198). Briefly referring to media, it should be noted that methods without media would be empty and worthless - teachers therefore need to decide on more than just the most appropriate method. There are a large variety of useful and effective media resources that teachers can draw from when instructional experiences for science learning are planned (Victor and Kellough 2000:121).

3.8 CONCLUSION

This chapter considered the views of influential theorists regarding learning and teaching. The purpose was (1) to investigate how children learn Natural Science and (2) to present a variety of suitable methods for effective Natural Science teaching.

In the next chapter, factors relating to *curriculum* are addressed, with specific attention given to the Natural Science Learning Area in the South African context (RNCS).

CHAPTER 4

THE NATURAL SCIENCE LEARNING AREA IN THE SOUTH AFRICAN CONTEXT

4.1 INTRODUCTION

In Chapters 2 and 3, a review of relevant literature regarding Natural Science education was presented. Firstly, the nature of science in general and specifically the components of science that need to be addressed at Foundation Phase level were clarified. Then, the ways in which children learn and construct meaningful understanding were reviewed by referring to well-known learning theories. Finally, various methodologies, suitable for effective science education, were presented.

This chapter focus on the Natural Science Learning Area in the Revised National Curriculum Statement (RNCS). The current policy regarding Natural Science education and related issues are explored. The first section is devoted to an elucidation of the concepts of *curriculum* and, in more detail, the *integrated curriculum*. International science curriculum developments are mentioned briefly, followed by indicating the need for appropriate science curricula in Africa. The major part of this chapter is a detailed presentation of the Natural Science Learning Area Statement (NSLA) in the South African context. Finally, the teacher as implementer of the curriculum is discussed briefly, focusing on the challenges facing the general Foundation Phase teacher in science education.

4.2 CURRICULUM

4.2.1 A working definition

Diverse definitions of the term *curriculum* are currently found. The definition of McLean (2004) of curriculum as a “systematically organized course of teaching and learning” perhaps encapsulates the most widely accepted understanding of the concept. While some definitions tend to be more narrow, focusing on the arrangement of subjects over a sequence of grades, others include virtually everything that students and teachers do.

In some countries, the expression *programmes of study and instruction* is used to refer to the same concept.

In the context of the present study, the definition of the National Association for the Education of Young Children (NAEYC) appears to be sufficient. The NAEYC defines curriculum as an

> organized framework that delineates the content children are to learn, the processes through which children achieve the identified curricular goals, what teachers do to help children achieve these goals, and the context in which teaching and learning occur (Bredekamp and Rosegrant 1992:10).

It is clear from the above that the NAEYC definition encompasses more than mere content, at the same time being more specific in stating various components essential to a curriculum (organised framework, content delineation, processes, goals, teacher input, learning context).

4.2.2 National curricula

Not all countries have a centralised policy on curricula. While some countries control and standardise curricula for each institution, others allow variation between regions, localities, and institutions. In most countries, national curricula consist of a list of subjects prescribed for each grade of education, each with an allocated number of hours per week or year (McLean: 2004). The overall aims for each level are suggested, together with the objectives and content for each subject. In South Africa, the C2005/RNCS provides the framework according to which the different provinces can implement the national curriculum.

National curricula express common global demands, such as basic standards of achievement needed to ensure that learners are prepared for occupations in high-technology economies. A widely shared aim is that an educational system should not produce disadvantaged underclasses. Apart from global ideals, national curricula also express local or national needs and ideals. The range of different approaches to curricula in various countries of the world reflects the history, politics, and culture of the particular country. Diversity in the social-cultural backgrounds of learners, and their personal ambitions, encourage more individualised or local curricula. Each country seeks a compromise consistent with both traditions and perceptions of the future (McLean 2004).

In the case of South Africa, the Constitution of the Republic of South Africa provides the foundational impetus for the formulation of ideals on a national scale. Constitutional aims are reflected in the national curriculum, acknowledging the crucial part of education in realising the full potential of each learner as a citizen of a democratic society. Broadly speaking the aims of the South African 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 by law; and
- build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations (DoE(b) 2002:1).

On a more local scale, while the National Department of Education in South Africa provides policy guidelines for the implementation of the RNCS, provincial departments are allowed a certain degree of freedom in implementing the national curriculum. Local authorities are also required to choose a significant percentage (30%) of content from local contexts. In this way the curriculum may be individualised to accommodate the diversity of social-cultural backgrounds in South Africa.

4.2.3 The integrated curriculum

As it is a premise of this study that Natural Science should not be taught and learnt in isolation, the whole notion of integration needs to be defined, and its application in a Learning Programme investigated.

4.2.3.1 Defining "integrated curriculum"

Victor and Kellough (2000: 147) define "integrated curriculum" comprehensively as:

> [B]oth a way of teaching and a way of planning and organizing the instructional program so that the discrete disciplines of subject matter are related to one another in a design that matches the developmental needs of the learners and that helps to connect their learning in ways that are relevant to their current and past experiences.

In this respect, an integrated curriculum presents the antithesis to traditional disparate subject-matter-oriented teaching and curriculum designations. Within the paradigm of outcomes-based education, integration can be defined as “the breaking down of boundaries or barriers between learning areas, subjects and disciplines”. The focus should be on how the clustering of outcomes from different learning areas into one Learning Programme contributes to add value to the Learning Programme and to make learning authentic (GDE/UNISA (2)2003:3).

The notion of integrated curricula employs a conceptual or life-problem-oriented approach to organisation, in which skills are utilised in appropriate contexts, new skills are taught as the need arises, and learners have the opportunity to select from or develop a variety of project and investigation options. All of these occur within the context of the area of study (Wolfinger and Stockard 1997:5). Learners have the opportunity for substantial involvement and input into the learning experience, including the types of projects and activities as well as concepts to be developed. In this approach, authentic forms of assessment are utilised in which the individual learner’s growth is charted rather than measured against external, established standards.

4.2.3.2 Traditional versus integrated curricula

The traditional approach to organising a curriculum is around subject matter areas (Wolfinger and Stockard 1997:4). Learning is divided into individual subjects, each with its own time slot, own text and own programme of study. An integrated curriculum, on the other hand, includes more than one discipline in an area of study. The fractionalised approached evolved into an integrated, holistic approach to learning. The reasoning behind the move is that natural learning does not occur in discrete, discipline-based segments. Any attempt to study subject areas in isolation is counterproductive and even futile. All learning is in the final analysis of an interdisciplinary nature (Martin 2001:346-347, 359).

While the traditional approach appears, on a superficial level, to have been effective for many years, it neglected the fact that problem solving in one subject area usually requires information from another. Communicating science information, to mention just one obvious example, often requires both writing and creative and artistic skills. In most cases, subject areas are artificially separated simply in order to be easily scheduled. Once it is recognised that subject matter overlaps over different areas, that some skills (reading, writing and mathematical) are useful in all areas, and that problem solving is interdisciplinary in nature, it becomes pertinent to explore other ways of presenting the curriculum to children, especially in the primary school (Wolfinger and Stockard 1997:4).

In South Africa, Curriculum 2005 (C2005) and the implementation of outcomes-based education are representative of the move to replace the traditional approach of non-integrated learning. As integration is central to the whole notion of outcomes-based education, teachers need to have a clear understanding of what it entails. They need to know what it means within the Learning Programmes, and they should be able to strike a balance between integration and conceptual progression. Teachers should be aware of and look for opportunities for integration both within and across Learning Areas (DoE 2003:6). Teachers following a more constructivist approach in their classrooms usually have a better understanding of how children learn best; consequently, they are in a better position to implement interdisciplinary approaches in all teaching and learning opportunities (Martin 2001:359).

4.2.3.3 Integration of the Natural Sciences

Integration feeds on interdisciplinarity. As the subject area of Natural Science is interdisciplinary in nature, it lends itself to an integrating approach. For example, science draws extensively from *mathematics* for measurement and interpretation of data, requires *language skills* for communication and is also closely related to *technology* and *social issues*. Science is also interdisciplinary relative to itself. While science is traditionally divided into the three areas of the Life sciences, the Physical sciences and the Earth and Space sciences, these areas are interdependent. A Life science topic, such as the investigation of the interactions of living things in a playground habitat, cannot be conducted without including the effects of weather on the habitat (an Earth and Space science topic). An investigation of rockets and space travel (Physical science) would also include how space travel affects the human body (Life science topic) (Martin 2001:345).

Apart from its internal interdisciplinarity, science also overlaps with non-science areas. Science derives its meaning in large measure from social contexts. Social studies provides the essential link between science concepts and principles, and their usefulness to society. How science is applied in our daily lives, how it contributes to and influence our social condition, and how science and technology drive one another, are important aspects of scientific investigation. Children should be assisted in constructing understanding of how the science topics they study are applicable to their daily lives.

The “so what?”-question, by which the teacher may ponder the relevance of a science topic, should be answered before presenting a lesson.

Integrating all learning areas in an interdisciplinary approach is a means of ensuring meaningfulness of learning topics, which raises the general level of teaching (Martin 2001:347). When disciplines are integrated and made relevant to the lives of learners, and when instructional techniques are socially interactive, learners achieve higher levels of thinking and more meaningful, longer lasting understanding (Victor and Kellough 2000:147).

4.2.3.4 Integration in Foundation Phase programmes

According to the GDE (GDE/UNISA (2):3-4), the following are to be achieved through learning integration in the Foundation Phase:

- whole approach problem solving;
- related learning to real life situations;
- transferring of knowledge and skills learned in one field of learning to that of another;
- linking different learning areas;
- applying existing knowledge and skills in new ways to meet and solve problems as they arise;
- making knowledge less abstract and more relevant; and
- encouraging teachers to work in teams.

In the Foundation Phase, knowledge integration is arguably of even greater importance for effective learning than in any other stage of the learning child. It is therefore essential that the historical fragmentation of knowledge be eliminated. An effective way of removing the obstacle is by paying attention to relevant integration both *within* and *across* Learning Areas (DoE 2003:6).

4.2.3.5 Strengths and weaknesses of the integrated curriculum

As with any approach, the integrated curriculum approach has both strengths and weaknesses which should be considered.

(i) Advantages (strengths) of the integrated curriculum approach

The fully integrated curriculum aims at integrating all subject matter. The common strategy is to start with a topic or real-life problem spreading across different learning areas. The subject matter follows from the topic, and skills are developed in correspondence to the demands set by the selected topic. The traditional subject matter treated in this way does not have the same appearance of isolated artificiality as it had in the traditional discipline-based approach.

The following strengths of the integrated curriculum can be distinguished:

- Authenticity of subject matter

  Authentic inclusion occurs when the concepts and skills of learning areas such as science, mathematics, languages, social studies, art and music are used as a means of gathering, presenting or understanding information. Learners are able to see how subject matter is related to their present search for knowledge and will be related to their future lives. Just as the mathematician, grammarian or scientist have a purpose for learning certain information, the child should have a purpose for learning information and she/he should be able to apply the acquired skills in real life situations (Wolfinger and Stockard 1997:6-7).

  The integrated curriculum also provides for a more developmentally appropriate programme for young learners. ECD/Foundation Phase learners do not see the world as divided into discrete bits of information, but rather from a global perspective. The integrated curriculum naturally maintains the global approach to understanding; it focuses on the interrelatedness of subject matter and assists learners in conceptualisation (Wolfinger and Stockard 1997:7).

- Conceptualisation rather than memorisation

  The integrated curriculum focuses on conceptualisation and in-depth understanding of major concepts of learning areas rather than memorisation. While memorised names, dates, definitions and procedures are easily forgotten, terms learnt in context facilitates conceptualisation, as more connections are made between previously learned and new information. This assures understanding and retention of content (Wolfinger and Stockard 1997:8).

- Learner autonomy

  Within the integrated curriculum, learners develop the ability to think for themselves and to guide their own learning as they are allowed an input. They begin to plan with the teacher, bringing their own ideas and interests to the topic and are given the opportunity to decide for themselves how they want to pursue those interests. In this way learners become more autonomous in their learning (Wolfinger and Stockard 1997:8).

- Problem solving skills

  When studying subjects in isolation, children often learn skills without purpose. If problem solving exercises are not related to real life problems, the exercises often remain unsolved. Within the integrated curriculum, learners are commonly provided with authentic problem solving situations where they work in small groups on a particular project, and identify and solve problems as part of the learning experience (Wolfinger and Stockard 1997:8).

- Development of interpersonal skills

  The common view of the classroom is a space where learners sit at separate desks arranged in orderly rows, working quietly in their own books and completing assignment individually (and often writing a test after completion of the lessons). Such a situation is rarely found outside the school. The integrated curriculum encourages cooperative work, where children work together and interact. Through interaction, children learn to communicate their ideas effectively, they learn to disagree or argue without fighting, and they learn to compromise. As their knowledge grows, so do their interpersonal skills (Wolfinger and Stockard 1997:8).

- Attention to a variety of learning modalities

  Children learn in various ways and demonstrate their learning in a variety of ways. Within the integrated curriculum, learners are provided with opportunities to pursue their learning through their strengths rather than being forced to display their weaknesses (Wolfinger and Stockard 1997:8).

- Authentic assessment

  The integration of learning areas requires that assessment procedures be holistic. In the integrated approach, the progress of the child is assessed in terms of the accomplishments of each child. Learners should rather be measured against themselves than against some predetermined standard - in this way the child's progression from the starting level to the final level is considered important (Wolfinger and Stockard 1997:8).

(ii) Disadvantages (weaknesses) of the integrated curriculum approach

- Absence of sequential learning

  Because the integrated curriculum is built around topics or real-life problems, new skills are introduced as they are needed within the projects developed. As a consequence, there is no standard sequence for the introduction of particular skills or concepts. Followers of more structured models of curriculum development fear that vital skills will be omitted from the curriculum, leaving learners without necessary skills. According to Wolfinger and Stockard (1997:12) the possibility does exist that children may not learn certain areas of the traditionally defined curriculum, but regard skills that do not arise in authentic situations as of no real value to the learner: "What they will not learn is the disjointed, often outdated and useless information that has caused the curriculum at elementary school to be overstuffed and superficial" (1997:12).

- Difficulty in coordinating the programme from grade level to grade level

  Without close coordination and careful selection, it is possible that the same topic or theme be repeated over years, resulting in learners in different grade levels dealing with the same problems of pollution, the body, the senses, and so forth. The programme should ensure progression and ongoing interest in topics (Wolfinger and Stockard 1997:11-13). Another concern is that teachers often find it hard to cover all of the content areas of the curriculum in the given time (Victor and Kellough 2000:193).

- Interdisciplinary instruction may not always be sufficient to meet science objectives.

  There are times when science outcomes can only be met through explicit science instruction. For example, when integrating Natural Science into the Languages, teachers cannot have learners simply read, write and share ideas about concepts, but learners must be actively engaged in investigation and experimentation. Thus, separate disciplinary instruction is sometimes necessary to meet each disciplines' outcomes (Akerson 2001:46).

- Problems with documentation

  The paperwork involved in documenting skills, concepts, projects and assessment for each child is far more extensive than in more structured curricula models (Wolfinger and Stockard 1997:11-13).

- Implementation of the programme

  The integrated curriculum requires that all teachers be firmly committed to the concept and the practice of integration. Without proper application, the programme may deteriorate into pockets of integration within a subject-matter-oriented programme, or otherwise, pockets of subject matter orientation within an integrated programme. Another concern is that teachers may focus on their own strengths and interests, rather than engaging children in learning that is meaningful to them (Wolfinger and Stockard 1997:11-13).

4.2.3.6 Integration and C2005/RNCS

The entire structure of C2005/RNCS is built on the interdisciplinary approach to integration, with the Critical Outcomes at the core of the curriculum, to be achieved by means of the Learning Areas (cf. GDE/UNISA 2003 (2):9). There is often the fear that content becomes insignificant in an integrated curriculum. However, this is not the case. Integration does not imply that the basics of a subject should not be learned or that content should be undermined. Neither does it imply the watering down or dropping of standards.

The critical importance of *content* is indicated by statements such as the following:

- "Outcomes-based education takes the position that education is learning for life and life needs people to be able to know and do"
- "Knowledge is seen as a vehicle and not an end"
- "Reduction of content can improve learning: e.g. in-depth versus surface learning"
- "Teaching involves more than covering a syllabus - it should prepare learners for life" (GDE/UNISA (2):10).

4.2.3.7 Categories of integration

The integrated approach to science education weaves physical, sensory and emotional activities into the total learning process. When science experiences are integrated with other curriculum areas, children's mental performance is enhanced. With integration, more opportunities are provided for higher-order thinking among learners, the use of multiple intelligences and cooperative learning (Harlan and Rivkin 2000:11,13; Wolfinger and Stockard 1997:104). Curriculum integration merges, intermingles, blends and fuses the content of different subjects in meaningful ways. There are, however, different ways in which this connection to other school subjects can be made. Two broad categories of integration as identified by GDE/UNISA (2003 (2):4-8) are mentioned here.

- Category 1: Integration is centred around themes, topics or skills within different Learning Programmes. Applications within this category are through Shared or Webbed Integration.

  Shared integration (content connections between Learning Programmes) comprises that educators from different disciplines choose to focus on the same skills. Teachers then plan for learners to master these skills and to apply them simultaneously to different or related topics (e.g. Literacy and Life Skills focus on listening skills).

  Webbed integration (cross-curricular connections) implies that a web is created, with a theme in the centre. Educators form a team to choose and plan the central focus - the focus area should be the same for all Learning Programmes.

- Category 2: Concept connections through the multi-disciplinary or inter-disciplinary approach.

  The multi-disciplinary approach implies that:

  (1) a concept is explored by using the content of other Learning Programmes;
  (2) each Learning Programme focuses on concepts and procedures that are important within the specific Learning Programme; and
  (3) links are made between Learning Programmes.

  An example of a multi-disciplinary approach is where learners use concepts in Literacy to help them master concepts in Natural Science.

  The inter-disciplinary approach implies that:

  (1) barriers between Learning Programmes are blurred;
  (2) teachers decide on the cognitive and other skills learners must acquire;
  (3) each teacher plans lessons so that learners can master the skills in that specific Learning Programme; and
  (4) learners must combine elements from different disciplines in order to complete tasks successfully.

  An example of an inter-disciplinary approach is where learners make a poster of the water cycle (Natural Science), they recite a poem about the sea (Literacy) and measure the rain water that was caught up in a container (Numeracy).

4.2.3.8 Barriers to integrating the curriculum

Teachers develop personal barriers to curriculum integration when they identify with their current teaching assignment to the extent of getting locked into being a “maths teacher” or “language teacher” only. Instead of viewing integration as a way of enhancing relevance and understanding for learners, teachers often display resistance in the fear that the subjects they hold dear will be tainted or diluted.

Integration is also regarded as putting an additional burden on teachers. Routman (1991, in Wolfinger and Stockard 1997:100) recognises that curriculum integration is often difficult to achieve because of constraints relating to theoretical understanding, time, administrative support, resources and curriculum requirements.

Ongoing staff development efforts need to include helping teachers to understand integration and develop meaningful integrated learning experiences.

While the holistic, multidimensional, collaborative and cooperative environment of an integrated curriculum offers expanded opportunities to teachers and learners, there are times when an integrated approach will not fit the needs and purposes of the task at hand, and where a discipline-based plan might work best. A teacher may very well be eclectic and use a variety of approaches, but should select the best strategy for the task at hand (Wolfinger and Stockard 1997:100-104).

To establish international best practice in Natural Science education in South Africa, notice should be taken of international trends with regard to curriculum developments.

4.3 TRENDS IN SCIENCE CURRICULUM DEVELOPMENTS

The scope of this study does not allow for elaborate discussions of science curriculum developments in other countries. Only a brief, general overview can be provided (with leaps in time and leaving out important contributions). This section intends to show that other countries have gone through extensive, thoughtful and critical review of past and present practices of Natural Science as a subject.

By considering the influences of the past and present, a better future for science education can be promoted.

(i) The general purpose of Natural Science education: scientific literacy

In recent times, *scientific literacy* is often described as the general purpose of science education. This is also the case in the South African context, where the purpose of the NSLA specifically deals with the promotion of *scientific literacy*. This focus on scientific literacy was not always found in science curricula. In England, Wales and the USA, considerable attention was focused on curriculum development in the last 50 years, and the meaning and significance of scientific literacy became more prominent (Wood:online; Goodrum, Hackling and Rennie 2001).

(ii) Curriculum developments in the United States of America

During the 1960's and 1970's, the emphasis on the processes of science resulted in such a dissatisfaction with the outcomes of science education that in the 1980's, science education in the USA was found to be in a crisis and called for reform. As a result, *Project 2061* was launched by the American Association for the Advancement of Science (AAAS). The core of its landmark publication: *Science for all Americans* (AAAS, 1989), champions scientific literacy. This publication laid the groundwork for the nationwide science standards movement, *Benchmarks for Science Literacy*. Documents, such as the national curriculum framework document in the USA, the National Science Education Standards (NSES), drew their content from *Benchmarks* and spelled out a vision for science education "that will make scientific literacy for all a reality in the 21st century". In the USA, the issue regarding content was also raised and schools were encouraged to rather teach less content in order to teach it better (Wood:online; Goodrum, Hackling and Rennie 2001).

(iii) Curriculum developments in the United Kingdom

Parallel changes have occurred in other countries as well. During the 1960s in the United Kingdom , science did not feature prominently in the curriculum until learners reached the secondary school. A survey of primary schools carried out by the UK Department of Education and Science (DES) in 1978, found that few schools had effective programmes for teaching science. The report showed that the three R's were taught well, and that there were no deficiencies in the basics. Science, however, was found to be badly taught or not taught at all. Where science featured, the emphasis was on biological topics. Teachers used mainly didactic methods and focused on the acquisition of facts. From the 1970s to the early 1980s, a debate on the development of the science process skills as opposed to mere knowledge of science content was at the order of the day. From 1980 onwards, the UK government became more involved in gaining knowledge about the curriculum, but also in influencing the curriculum. A series of publications from the DES, Schools Council and Her Majesty's Inspectorate (HMI) on the curriculum in the first half of the 1980s followed. Since then, many developments have taken place and resulted in policy statements regarding science with the emphasis on "Science for All", a national system of assessment and the promotion of in-service training courses in science for primary school teachers (Morrison and Webb 2000:8).

Throughout the 1980's, more serious debates about the nature and place of science in the primary curriculum emerged. The purposes, goals and expectations of primary science were clearly formulated and it was felt that all children between five and sixteen years of age should learn about science in all its forms, whether they were likely to pursue science as a career or not. Science has been one of the most rapidly developing subjects in Primary schools in the UK in the last two decades, during which it has changed from a minority subject, taught by interested teachers, to a core subject alongside with mathematics and English. Science is seen by many authors as one of the successes of the implementation of the National Curriculum in the United Kingdom (Sharp and Grace 2004:295,315).

The success of this implementation is contradicted by Lynn Newton, a professor of Primary Education at the University of Durham. According to her, the reality is that science today, even if it is meant to be a core subject, is rarely afforded an equal status with English and mathematics. Science has once again languished, as the focus returned to the quality of English and mathematics teaching to the exclusion of all else. The amount of time given to science has often declined and teachers spend the available time to teaching scientific vocabulary and facts and avoiding teaching for understanding (Newton in Martin 2005:xv). The increased awareness and debate about advances in science and the implications for curriculum developments therefore continue in the UK, as the need for effective primary science education is acknowledged.

(iv) Curriculum developments in Australia

Happenings in the USA and the United Kingdom strongly influenced science curriculum developments in Australia as well. In Australia, science education in primary and secondary schools has been a growing concern. In an effort to identify the main areas of concern, the Australian Government commissioned a formal report on the quality of science education in Australia (*The Status and Quality of Teaching and Learning of Science in Australian Schools,* released in March 2001). The findings of this report were as follows:

- There are many examples of excellent science education in Australia, but a lack of consistency throughout primary and secondary schools was noted.
- When science is taught regularly in primary schools it usually results in a high level of student satisfaction.

- There is a significant variation in primary science with some schools not teaching science at all.
- Students who showed an interest in science throughout primary school often felt disappointed by the quality of science education available to them in high school.

The report highlighted the need to engage students and help schools deliver a consistently high quality science education. In response to this, the Australian Government provided teachers with the support required through its National School Science Project (Goodrum, Hackling and Rennie 2001).

By the end of 1970, a variety of curricula was used in Australian schools, many of which were viewed as unsatisfactory. A National Symposium on the place of science in the K - 12 curriculum was convened by the Australian Science Teachers Association (ASTA) which resulted in a follow-up survey and report. The survey explored problems relating to a lack of public support for science, lack of recognition from the Federal Government and the belief that science curricula were not meeting the needs of learners - which included aspects such as excessive emphasis on the teaching of content, with insufficient time for development of the scientific processes, manipulative skills, scientific attitudes or of human aspects, environmental issues and the application of science (ASTA 1985 in Goodrum, Hackling and Rennie 2001).

Because of concerns about the teaching of primary science, several efforts were launched in different regions in Australia to address the issue. In South and Western Australia, efforts concentrated on the in-service area, rather than on pre-service preparation. One such a programme is the *Primary and Early Childhood Science Teacher Education Project* (PECSTEP) at the Canberra University, which inspired a similar programme at the University College of Central Queensland. Both these programmes focused on pre-service as well as practising teachers (Appleton and Kindt 1999:156). The *Science in Schools* (SiS) Research Project is another example of a state government initiative in Victoria, Australia. This project is aimed at developing an effective change strategy to support 225 schools in improving their science teaching and learning. A central aspect of the change strategy is a framework for describing effective teaching and learning in science - where teacher change is also monitored. If validated descriptions of the practice of teacher efforts are produced, then instruments, advice and programmes to improve teaching and learning can be developed (Tytler 2004:171).

It can be concluded that the state of science teaching in the early childhood and primary phase has consistently been an area of concern in developed as well as in developing countries. For example, in the UK, USA and Australia, the poor quality of delivery of science in primary schools has been raised on several occasions. The general concern resulted in several initiatives attempting to address the situation. Areas coming under scrutiny include curriculum development, professional development of teachers (both pre-service and in-service training), provision of curriculum resources and teacher educational materials, and projects to improve the quality of science teaching in their schools (Appleton and Kindt 1999:166; Tytler 2004; Goodrum, Hackling and Rennie 2001).

4.4 SCIENCE CURRICULUM DEVELOPMENTS IN AFRICA

4.4.1 The need for science curriculum developments in Africa

There can be no argument about the importance of educating a scientifically literate workforce on the continent of Africa. The challenge is daunting, as Africa is lagging behind the rest of the world and remains, "(b)y any measure ... the most underdeveloped region in the world" (Gray, Naidoo and Savage 2004:1).

Whatever the reasons for the developmental gap between Africa and the rest of the world, current realities such as the following need addressing:

- inappropriate science and technology education have failed to bring the desired economic transformation;
- inappropriate science and technology education has failed to spearhead an appropriate application of science and technology towards development.

Across the continent, the need for quality science and technology education is evident. However, quality education in these fields can only be achieved when it is given priority by the government and policy makers.

In order for sustainable development to be implemented, countries in Africa need the following (Gray, Naidoo and Savage et al 2004:2-3):

- better utilisation of science and technology for development that addresses developmental needs and that build on Africa's potential strengths;
- science and technology education for better governance. Education geared for the promotion of literacy in problem-solving attitudes and scientific skills which require learners to improve their quality of life is needed;
- science and technology education that will provide for better science and a sound basis for further development;
- science and technology education for a more skilled workforce. Scientific and technological literacy is imperative for the 21st century and beyond. Science education for all (irrespective of gender, class, geographic location or race) should become priority;
- a science and technology education that institutionalises innovation so that the search for appropriate and effective solutions may take place on an ongoing basis; and
- a more effective theory of systematic educational change to guide the investment of scarce resources in science and technology education.

Political ideals, such as socio-economic equality and prosperity, can only be realised by equipping Africa's strongest resource - its future generations - for the task ahead. Education is vital in addressing the problem; in particular, science and technology education has an indispensable part to play in the development of the African continent (Savage, Naidoo and Gray 2004:191).

At school level, the contribution of governments in terms of national curricula should provide the framework for quality science education. The recently developed curriculum statements (hereafter referred to as RNCS), published by the Department of National Education in South Africa, reflect the priorities of the broad national goals of education. By means of the RNCS, the South African government upholds a democratic vision of the society and the citizens that should emerge from the school system (Savage, Naidoo and Gray 2004:191).

4.4.2 Developments in South Africa

In South Africa, recent interest in the state of science and mathematics education was kindled as a result of the country's participation in international comparative studies such as the Third International Maths and Science Study (TIMSS, 1995); TIMSS-R (1998) and Trends in Mathematics and Science Study (TIMSS, 2003).

These studies are regarded as reliable barometers of the state of a discipline in a particular country, and consequently taken seriously by governments. South Africa's participation exposed the general state of science education in this country, and elicited alarmed comment from the current minister of Education (Department of Education: Statement on the release of the *Trends in Mathematics and Science Study,* TIMSS 2003). Ms Pandor expressed great concern about the results obtained by South African learners, pointing out the serious challenges facing South Africa in the areas of mathematics, science and technology throughout the education and training system. Significantly, she also stressed the major gains to be had in addressing these challenges.

The South African Department of Education already implemented some strategies to address the current situation. Since 2001, 4500 teachers completed Advanced Certificates in Education and B Ed degrees, in which mathematics and science received their due emphasis. This is also the case with the National Professional Diploma in Education, which includes a course in mathematics. Good quality teachers have been identified as the key to improving performance, while the number of specialist "Dinaledi" schools are to be increased to a 1000 in the next five years (Pandor 2004). However, all these interventions are aimed at learners and teachers above the Foundation Phase.

While the general issue of science teaching is high on the South African educational agenda, any specific focus on Foundation Phase science teaching remains conspicuously absent. The current study to establish the state of science teaching in the Foundation Phase is the only South African study the researcher is aware of. No examples of government initiatives aimed at improving Natural Science teaching and learning in the *Foundation Phase* are known. The state of science education in South Africa is at an extremely low level and can be regarded as being in a crisis. The need for good quality science education from the early years is extremely important, and studies to reveal the status of science teaching and learning specifically at the Foundation Phase level are urgently needed.

4.5 THE RNCS IN LEARNING AREA CONTEXT

Before the Natural Science Learning Area will be discussed in depth, it is important to note that the recent curriculum developments that have taken place in the South Africa context, impacted on the current Learning Area Statements. C2005 was streamlined and strengthened into the RNCS. While some changes have occurred on different levels of C2005, the principles, purposes and thrust of C2005, and the commitment to OBE remain intact (DoE (a) 2002:6). The greatest developments that took place regarding the *Natural Science Learning Area* are presented below.

4.5.1 The Natural Science Learning Area: From C2005 to RNCS

In the Natural Science Learning Area, considerable changes have been introduced. In the Foundation Phase Policy documents of C2005, there were nine Specific Outcomes (SO's) for the Natural Science Learning Area. A summary of the SO's are provided in TABLE 8 (below).

TABLE 8

C2005 (October 1997): Nine SO's in the Foundation Phase Natural Science Learning Area	
SO 1	Use process skills to investigate phenomena related to Natural Sciences
SO 2	Demonstrate an understanding of concepts and principles, and constructed knowledge in the Natural Sciences
SO 3	Apply scientific knowledge and skills in problems in innovative ways
SO 4	Demonstrate an understanding of how scientific knowledge and skills contribute to the management, development and utilisation of natural and other resources
SO 5	Use scientific knowledge and skills to support responsible decision-making
SO 6	Demonstrate an understanding of the relationship between science and culture
SO 7	Demonstrate an understanding of the changing and contested nature of knowledge in the Natural Sciences
SO 8	Demonstrate knowledge and understanding of ethical issues, bias and inequities related to Natural Sciences
SO 9	Demonstrate an understanding of the interaction between the Natural Sciences and socio-economic development

The Western Cape Curriculum Planners of the WCED, provided a table to show how the Learning Outcomes were streamlined in the RNCS. See TABLE 9 below.

TABLE 9

RNCS (March 2002) Three Learning Outcomes (LO's) for the Natural Science Learning Area		
LO1 (FP)	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.
LO2	Constructing science knowledge	The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.
LO3	Science, society and technology	The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.

It seems as if the focus of the SO's in C2005 was on science only, whereas the RNCS focuses on science, technology and the environment (WCED 2003:6).

The WCED also explained how the SO's were reorganised into the LO's of the RNCS. The comparison showing the links between the LO's in the RNCS and the SO's in C2005 is given in the TABLE 10 below:

TABLE 10

C2005		**RNCS**
SO1 SO3 SO5	Process skills →	LO1
SO2 SO7	Content →	LO2
SO4 SO6 SO8 SO9	Science and Society →	LO3

The greatest changes from C2005 to RNCS, specifically in the Natural Science Learning Area, were:

- the reduction of the 9 SO's to the 3 LO's (with only LO1 prescribed for the Foundation Phase); and
- the prescription of content in the RNCS. In C2005, no content was prescribed. This caused tremendous difficulties for learning programme writing, portability, assessment and standardisation. In the RNCS, all the content is prescribed. Portions of the prescribed content can be used to address LO2 and LO3 indirectly (WCED 2003:7).

4.5.2 The value placed on Natural Science in the South African curriculum

While the importance of science education for young learners is globally emphasised, many countries contribute to its practical devaluation by allotting insufficient time to science teaching (in comparison to the time and weighting allotted to language and mathematics teaching). The next section investigates the relative importance given to Natural Science education in the RNCS.

The RNCS evidently regards science as an extremely important part of the National Curriculum. This may be seen in the broad national goals of education expressed by the RNCS, the Critical Outcomes and Developmental Outcomes (derived from the Constitution), but also throughout the Natural Science Learning Area Statement.

Indications of the relative prominence attributed to Natural Science are to be found in the following areas:

(1) The relationship of the Natural Science Learning Outcomes to the Critical and Developmental Outcomes. The Critical Outcomes were provided in Chapter 1 (see par. 1.5.10).

The Natural Science Learning Outcome 1 most clearly represents Critical Outcome 6, but also gives meaning to Critical Outcome 1 by emphasising that learners should increasingly formulate questions and problems for themselves. When learners do investigations, they build Critical Outcomes 2,3,4, and 5 (DoE/GIED 2002:108).

(2) The *purpose* of the Natural Science Learning Area is to deal specifically with the promotion of *scientific literacy*. This is to be achieved through:

- the development and use of science process skills in a variety of settings;
- the development and application of scientific knowledge and understanding; and
- appreciation of the relationships and responsibilities between science, society and the environment (DoE (b) 2002:4).

(3) The *development of science process skills* in the teaching and learning of science is proposed by the Natural Science Learning Area. A range of process skills may be used in everyday life, in the community and in the workplace. These skills can be gained in an environment that supports creativity, responsibility and growing confidence. The ability to think objectively and use a variety of forms of reasoning is developed while using the process skills to investigate, reflect, analyse, synthesise and communicate (DoE (b) 2002:4).

(4) The importance of science is also seen in the RNCS's view of the development of scientific knowledge and understanding as a *cultural heritage* that can be used to:

- answer questions about the nature of the physical world;
- prepare learners for economic activity and self-expression;
- lay the basis for further studies in science; and
- prepare learners for active participation in a democratic society that values human rights and promotes environmental responsibility (DoE (b) 2002:4).

(5) The place of science within *society,* and the major impact of science and technology on the world, are also acknowledged in the RNCS. The document proposes the careful selection of scientific content, and a variety of ways in teaching and learning science, as a means of promoting the understanding of

- science as a human activity;
- the history of science;
- the relationship between Natural Sciences and other Learning Areas;
- the contribution of science to social justice and societal development;
- responsibility to ourselves, society and the environment; and
- the consequences of decisions that involve ethical issues (DoE/GIED 2002:105 -106).

(6) The *unique features and scope* of the Natural Science Learning Area (NSLA) envisage a teaching and learning milieu which recognises that the people of South Africa operate with various learning styles and culturally-influenced perspectives. It starts from the premise that *all learners should have access to a meaningful science education,* and that arbitrary selection and rejection based on various kinds of biases should be avoided. Meaningful education (and that includes meaningful science education) should be learner-centred and help learners to understand not only scientific knowledge and how it is produced, but also the contextual environment and global issues that are intertwined within the Learning Area. The following statement of the Natural Science Learning Area is of utmost importance in this regard:

> **The Natural Science Learning Area must be able to provide a foundation on which learners can build throughout life** (DoE (b) 2002:5).

(7) The RNCS acknowledges the fact that the Natural Sciences offer us a particular way of understanding the world we live in, and that the NSLA differs from other Learning Areas because of:

- the way in which information is gathered and interpreted;
- the way in which information is verified before general acceptance;
- the acknowledgement of the limitations of scientific enquiry; and
- the domain of knowledge that is covered (DoE/GIED 2002:106).

Through the above (1 - 7), it is evident that South African educational authorities regard Natural Science education and the development and promotion of scientific literacy as of extreme importance. As these points form part of national policy, teachers and other role players should take notice of the emphasis, and get equipped to apply the policy effectively in classroom practice.

Less clear from the official documents, however, is how important science teaching in the Foundation Phase is regarded. The high value placed on science in the RNCS should be reflected by the place and time devoted to the teaching of the Learning Area in a phase. Only LO1 of the NSLA is prescribed for the Foundation Phase and it is suggested to be taught in an integrated way (see par. 4.5.2 *The value ...* and 4.7 *Integration of ...*). The single Learning Outcome and the limited time and weighting attached to the teaching and learning of Natural Science, might point to a lack of emphasis, which should be a cause of concern.

4.6 THE IMPLEMENTATION OF THE NATURAL SCIENCE LEARNING AREA IN THE FOUNDATION PHASE

In the following section, the Natural Science Learning Area (NSLA) is discussed in depth. All aspects relating to the Natural Science Learning Area for the Foundation Phase are presented. The discussion closely follows the content of the Natural Science Learning Area policy document as set out in the Revised National Curriculum Statement.

4.6.1 Introduction

The RNCS acknowledges the natural sense of curiosity of the Foundation Phase learner which leads to an exploration of the world by observing and manipulating common objects in the environment. According to the NSLA document, the learner in this phase achieves by exploring, and these abilities are displayed if the curriculum is rich in objects and materials to work with. These learners find it hard to plan, because the approach to learning is one of "action first and then see what happens", rather than spending time thinking through what will happen before action is undertaken. The learner is also described as being mostly interested in his/her own viewpoint on any matter so that events and objects are described without reference to how they might appear to other people. In the same sense, what the learner knows is the same as what is seen or felt. Science in the Foundation Phase should build on the learner's curiosity and ways of knowing, and encourage investigation of the natural world with a sense of wonder. Learning science as investigation provides the learner with the opportunity to develop the process skills so fundamental to scientific enquiry, and creates essential opportunities for language development as the learner is given opportunity to share his/her experiences in class. Process skills and discussions are fundamental to concept development. The Natural Science Learning Area document advises *classroom methodologies* that will encourage learners to use their most fluent language in order to express their own ideas in discussion with classmates. This would make learners participants in the intellectual activity of the lesson and lower the barriers to participation created by unfamiliar language (DoE (b) 2002:23).

*Although the Natural Science document refers to *classroom methodologies*, no methods, specifically for Natural Science teaching are mentioned or explained.

The NSLA regards the following as important in the Foundation Phase:

- the ability to describe and manipulate objects by pushing, pulling, throwing, dropping, and rolling, so that the position and movement of objects receive attention;
- the development of efficient vocabulary to describe location as up, down, in front of, behind;
- recognition of names of different properties, e.g. size, shape, texture, colour, and the ability to sort and categorise these accordingly;
- the ability to describe, from investigation, the properties of different kinds of materials (e.g. paper, wood, metal, water); and
- the ability to describe changes, including cyclic changes that occur in the natural environment (DoE (b) 2002:23).

4.6.2 Natural Sciences Learning Outcomes and Assessment Standards for the Foundation Phase

4.6.2.1 LO1 of the Natural Science Learning Area

In the Foundation Phase, only Learning Outcome 1 is taught and assessed (DoE (b) 2002:24). This Learning Outcome focuses on “scientific investigation”. The scientific investigation process is central to the Natural Science Learning Area and it is enshrined in this Learning Outcome (WCED 2003:8).

Learning Outcome 1: 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 contexts (DoE (b) 2002:24).

➟ The meaning of Learning Outcome 1

Learner competence in Learning Outcome 1 is described in the Natural Science Learning Area Statement. Competence can be seen as the learner searches for information from books and resource people, generates products and questionnaires, collects data and materials from nature or industry, creates testable questions and fair tests, and explains conclusions (DoE (b) 2002:8).

Competence in this Learning Outcome also implies that the learner should be able to show initiative and to put his/her mind to *practical problems* of at least four kinds, e.g:

- problems of making;
- problems of observing, surveying and measuring;
- problems of comparing; and
- problems of determining the effect of certain factors.

Each kind of problem requires conceptual knowledge of science as well as creative thought and systematic testing of ideas. These kinds of problems represent a range of the kinds of intellectual demands that Learning Outcome 1 makes on learners. Activities that build competence in this Learning Outcome are provided by the Natural Science Learning Area by means of a set of process skills which are essential in creating outcomes-based science tasks (DoE (b) 2002:8-9,13).

4.6.2.2 The Assessment Standards for Learning Outcome 1

For Learning Outcome 1, the Assessment Standards are the following:

- planning investigations;
- conducting investigations and collecting data; and
- evaluating data and communicating findings.

These are expressed in appropriate terms for the Foundation Phase as:

- plan;
- do; and
- review (DoE (b) 2002:24).

In TABLE 11, the Assessment Standards for Grade R-3 are provided. These Assessment Standards (AS) provide a common national framework for assessing learners' progress (DoE (b) 2002:24-27).

(It is important to note: The AS's according to policy appear in bold, while the illustrative examples, headed by the phrase *Achievement is evident when the learners, for example*, are NOT policy. Their purpose is to indicate progression across the grades) (DoE (b) 2002:24-27).

TABLE 11: ASSESSMENT STANDARDS FOR NATURAL SCIENCE (GR R-3)

Learning Outcome 1: **SCIENTIFIC INVESTIGATIONS**			
Grade R	Grade 1	Grade 2	Grade 3
■ **Plans: Contributes towards planning an investigative activity.** Achievement is evident when the learner, for example, • asks and answers questions about the investigation, using "show and tell" or stories to say what action is planned	■ **Plans: Plans an investigation independently.** Achievement is evident when the learner, for example, • show how self plans to find out about things which are found to be curious; • uses pictures, drawings or other markings of choice to explain what is going to be done	■ **Plans: Plans an investigation as part of a group** Achievement is evident when the learner, for example, • discusses and plans with others • negotiates understanding of who does what • decides on what materials or modes will be used to communicate the plan	■ **Plans: Uses materials selected by the group in order to communicate the group's plan** Achievement is evident when the learner, for example, • lays out materials the group intended to use; • tells who will use the materials and the purpose
■ **Does: Participates in planned activity.** Achievement is evident when the learner, for example, • follows simple instructions with assistance; • explains what is being done or played (e.g. games according to rules).	■ **Does: Independently participates in planned activity.** Achievement is evident when the learner, for example, • carries out instructions independently and shows or tells what is being done	■ **Does: Participates in planned activity independently or as part of a group.** Achievement is evident when the learner, for example, • plays a role in a group and carries out instructions independently • explains what is being done, and answers the question, "What are you trying to find out?".	■ **Does: Participates constructively in the activity with understanding of its purpose.** Achievement is evident when the learner, for example, • explains the purpose of the activity • answers the questions, "Why are you doing this?" and "How are you trying to find that out?" and "Is your plan working?"; • Agrees or disagrees with other opinions, giving reasons.
■ **Reviews: Thinks and talks about what has been done.** Achievement is evident when the learner, for example, • uses simple words, pictures or other items with assistance to explain what has been done.	■ **Reviews: Thinks about what has been done and says what has been found out.** Achievement is evident when the learner, for example, • individually or with assistance, "shows and tells" what was done using own ideas and objects to explain what aroused curiosity.	■ **Reviews: Thinks about what has been done and says what has been found out.** Achievement is evident when the learner, for example, • explains own contribution to the investigation; • uses several different ways to communicate own ideas; • is curios about what might happen if the situation was changed in some way	■ **Reviews: Thinks about what has been done and says what has been found out.** Achievement is evident when the learner, for example, • reviews how actions of members in the group contributed to the purpose; • reviews what is needed to do better next time; • uses a number of different ways of presenting information; • reflects on what other topics might be investigated.

The NSLA acknowledges the fact that not all children would have attended Grade R, and therefore teachers need to teach and consolidate the Grade R concepts, skills and strategies in Grade 1 (DoE (b) 2002:24).

4.6.3 A framework for process skills in the Foundation Phase

As the *scientific investigative process* is the essence of the NSLA, one needs to be familiar with the process skills and sub-skills that embedded in the scientific investigation (WCED 2003:8). The process skills were discussed extensively in Chapters 2 and 3 (see par. 2.5.3.2 and 3.5.3). For the sake of convenience, the definition of the *process skills* according to the NSLA will be restated here.

According to the Department of Education ((b)2002:13), these skills are "the learner's cognitive activity of creating meaning and structure from new information and experiences."

4.6.3.1 Steps involved in the investigative process

As a process, process skills involve several steps, each step itself being a skill in its own right. As seen earlier, the fundamental skill embedded in LO1 is scientific *investigation*. A scientific investigation commences when there is a *problem to be solved* (see *kinds of practical problems* discussed under *Competence in LO1*, p152) and the pursuit/quest for its solution leads to the formulation of a *hypothesis*. An investigation is thus *planned* (**PLAN**), the hypothesis is tested through *experimentation* (**DO**) and results obtained are *evaluated* and *communicated* (**REVIEW**). The skills in italics can be broken down further into many sub-skills depending on the situation at hand (DoE (b) 2002:13; WCED 2003:8).

In the Foundation Phase, only three steps in this investigative process have been set aside for assessment. These steps are the *Assessment Standards* for the Foundation Phase and expressed as:
STEP 1: planning (PLAN)
STEP 2: conducting (DO)
STEP 3: evaluating and communicating (REVIEW) (see par. 4.6.2.2).

The sub-skills in each of these three steps have been identified and then allocated to grades by means of Assessment Standards (WCED 2003:8).

4.6.3.2 Essential basic process skills for the Foundation Phase

The WCED provides an example of the *essential basic process skills* for the Foundation Phase, adapted to suit the needs of the school. The table provides a framework for teachers to obtain examples of process skills and sub-skills when writing learning programmes, work schedules and learning units. In the case of Learning Outcome 1, teachers need to take note that each process skill must be seen as one step in the investigative process only. Learners should however do *complete investigations* although only a part thereof would be set aside for assessment (WCED 2003:9).

A framework of process skills enables teachers to design questions which promote those kinds of thinking required by the Learning Outcomes. Such a framework is also valuable to teachers in assessment; when designing rating scales; or marking memos and instruments to record the day-to-day participation of learners (DoE (b) 2002:13).

As an example, the *Process skills framework for Foundation Phase* as designed by the WCED (2003:9) will be provided in TABLE 12 (unchanged).

TABLE 12

	Grade R (Sub-skills)	**Grade 1** (Sub-skills)	**Grade 2** (Sub-skills)	**Grade 3** (Sub-skills)
LO1, AS1 Planning investigations	**Observing** (seeing, feeling, smelling things)	**Identifying** (problem involved, tools required, variables involved) **Questioning** (asking questions that lead to investigations)	**Testing** (exploring beforehand, trialing) **Deciding** (how to obtain results, what apparatus to use, where to look)	**Predicting** (telling beforehand) **Hypothesising** (making statements that can be proved right or wrong) **Designing** (action plans, tests, surveys)

LO1, AS2 Conducting investigations and collecting data	**Following instructions** (adhere to verbal, written instructions) **Observing** (seeing, feeling, smelling things)	**Collecting** (gathering results, information) **Handling** apparatus / tools (setting up, using apparatus/tools)	**Measuring** (finding the size/amount of things) **Recording** (writing down results, observations)	**Making** (apparatus, tools, devices, solutions) **Experimenting** (finding out, testing, trialing things)
LO1, AS3 Evaluating data and communicating findings	**Interpreting** (seeing patterns, relationships) **Sequencing** (arranging data or results in numerical or alphabetical order)	**Communicating** (talking, presenting, demonstrating things to others) **Identifying** (spotting trends, errors) **Sorting/classifying** (grouping things together according to a rule) **Comparing** (noting similarities and differences)	**Inferring** (making deductions, conclusions) **Reflecting** (thinking about reliability and validity of findings) **Tabulating** (recording data or results in tables) **Recording** (writing down results in various formats, e.g. table, graph)	**Graphing** (drawing graphs from data, results) **Analysing** (examine data, results, findings) **Concluding** (inferring, making deductions) **Evaluating** (assessing reliability of results or findings)

Teachers who understand and appreciate the importance of the science process skills should have a far better capacity to help children think than teachers who do not - even if they use the same curriculum guide (Gega 1994:91). It is therefore crucial that Foundation Phase teachers understand what the process skills involve, and know how to apply them in practice. An extensive set of process skills were provided in Chapter 2 (see par. 2.5.3.2) and the development of process skills in Chapter 3 (see par. 3.5.3).

4.6.4 Natural Science Learning Area content

According to Bickart, Jablon and Dodge (1999:373), a science curriculum in the primary grades is most effective when it builds on the learners' natural inclination to seek explanations, and fosters their desire and willingness to seek answers to questions through active investigations. The focus of the curriculum should be on teaching children *how to think like scientists*, therefore nurturing the learners' sense of wonder - their interest and excitement in finding out about the world. The WCED (2003:13) regards content in the NSLA as important, but sees the *scientific investigation* as more important than the content because new concepts and content in science can only be created through investigation and experimentation (compare par. 2.5.3).

The NSLA devotes equal importance to the development of knowledge and understanding (see core knowledge and concepts in par 4.6.4.1) and the acquisition of process skills. LO1, the only Learning Outcome prescribed for the Foundation Phase, deals with scientific investigations and therefore acknowledges the importance of the scientific investigative process. Investigations can, however, not be conducted in a vacuum and requires *content* to conduct investigations. This explains why content is prescribed in the NSLA.

4.6.4.1 The main content areas or knowledge strands in the Natural Science Learning Area for Foundation Phase

Every country decides on the content or knowledge appropriate for the learners in a specific age group. In the RNCS, the fields which scientists study have been grouped into four main content areas or knowledge strands. The identified fields of enquiry are grouped under four different headings as each of these fields need very different data and use different methods of investigation (DoE (b) 2002:5).

(1) Life and Living

Live and Living focuses on life processes and healthy living, on understanding balance and change in environments, and the importance of biodiversity.

(2) Energy and Change

Energy and Change focuses on how energy is transferred in physical and biological systems, and on the consequences that human needs and wants have for energy resources.

(3) Planet Earth and Beyond

Planet Earth and Beyond focuses on the structure of the planet and how the earth changes over time, on understanding why and how the weather changes, and on the earth as a small planet in a vast universe.

(4) Matter and Materials

Matter and materials focuses on the properties and uses of materials, and on understanding their structure, changes and reactions in order to promote desired changes (DoE (b) 2002:1, 4-6).

The Natural Sciences has a separate chapter which contains the *Core Knowledge and Concepts* - these provide the context in which at least 70% of teaching, learning and assessment should take place - the other 30% come from local contexts, for example, economic, environmental, social or health contexts significant to the learners and the local community (DoE 2003:7; DoE/GIED 2002:107).

Teachers are required to provide a variety of learning experiences and activities that will cover the content and concepts of all four the knowledge strands as well as the stated Assessment Standards of LO1. According to LO1, each and every investigation must cover the complete investigative process (that is planning, doing and reviewing). For assessment purposes, they may choose to focus on any one or more (WCED 2003:15).

The core knowledge and concepts are given in TABLE 13. The table provides a suggested arrangement of content and concepts. Teachers are free to adapt or develop their own arrangements.

TABLE 13: CORE KNOWLEDGE AND CONCEPTS (next page)

CORE KNOWLEDGE AND CONCEPTS IN:
LIFE AND LIVING
Life Processes and Healthy Living *Unifying statement: Living things include humans and invisibly small organisms, that can be understood in terms of life processes, functional units and systems.*
• Many of our body parts correspond to parts of animals, such as limbs, heads, eyes, ears, feet, and in many cases animals use them for the same purpose we do. • Animals and plants have similar needs to ours, for food, water and air.
Interactions in Environments *Unifying statement: Organisms in ecosystems are dependent for their survival on the presence on abiotic factors and on their relationship with other organisms.*
• We depend on plants and animals for food, and we breed certain animals and grow certain plants as crops. • We see cultural diversity in the kinds of food people like to eat. • Some animals, like flies and ticks, carry germs which can make people sick.
Biodiversity, Change and Continuity *Unifying statement: The huge diversity of forms of life can be understood in terms of a history of change in environments and in characteristics of plants and animals throughout the world over millions of years.*
• There are a large variety of plants and animals which have interesting visible differences but also similarities, and they can be grouped by their similarities. • Plants and animals change as they grow, and as the years pass, and as the seasons change.
ENERGY AND CHANGE
Energy Transfer and Systems *Unifying statement: Energy is transferred through biological and physical systems, from energy resources. With each energy transfer, some of the energy becomes less available for our use, and therefore we need to know how to control energy transfers.*
• When we say we feel "full of energy", we mean we feel ready to move fast or do a lot of work.
Energy and Development in South Africa. *Unifying statement: Energy is available form a limited number of sources, and the sustainable development of countries in our region depends on the wise use of energy sources.*
• People who do not have enough food or the right kind of food to eat, feel tired and lack energy.
PLANET EARTH AND BEYOND
Our place in Space *Unifying statement: Our planet is a small part of a vast solar system in an immense galaxy.*
• Many different objects can be observed in the sky. Examples are birds, clouds, aeroplanes, the sun, stars, the moon, planets and satellites. All these objects have properties, locations and movements that can be investigated with a view to determining patterns, relationships and trends.

Atmosphere and Weather *Unifying statement: The atmosphere is a system which interacts with the land, lakes and oceans and which transfers energy and water from place to place.*
• Weather changes from day to day in ways that can be recorded and sometimes predicted. There are occasional unusual weather events like storms, floods or tornados which impact on people's lives.
The Changing Earth *Unifying statement: The earth is composed of materials which are continually being changed by forces on and under the surface.*
• Soil and rocks vary in appearance and texture from place to place. By investigation, learners can find out that some soils erode more easily than others do, while some soil types support plant life better than others. They could investigate what some of the factors involved might be.
MATTER AND MATERIALS
Properties and Uses of Materials *Unifying statement: We can classify materials by their properties, in order to establish types and patterns. Properties determine the selection of materials for particular uses.*
• Materials have different properties such as texture, colour, strength and heaviness, and can be classified by these properties. We can make things with materials which have the properties we want.
Structure, Reactions and Change of Materials *Unifying statement: We can modify materials in ways we choose, through our understanding of their substructure.*
Substances can be mixed and sometimes changes can be seen, such as the dissolving of a solid or new colours when food colouring/paints are mixed.

(DoE 2002 (b):62-73)

It should be noted that:

- the core knowledge statements are neither Learning Outcome statements nor Assessment Standards;
- the statements are core, *minimum knowledge* for Learning Programmes in the Natural Sciences Learning Area. Learning programmes must draw content from all four strands over a phase; and
- the core knowledge statements may be clustered and taught in various sequences (DoE/GIED 2002:119).

As seen earlier, Foundation Phase teachers are required to provide learning opportunities that will cover the content and concepts of all four the knowledge strands. The question arises whether Foundation Phase teachers themselves understand all of these concepts well enough to teach learners confidently and effectively. Many studies have revealed that teachers mostly prefer topics from Biological sciences (plants and animals), thus resulting in learning programmes that omit some of the content areas and offering learners an inadequate range of learning opportunities (Summers and Mant 1995:13).

The research of Summers and Mant (1995:13) has also shown that there is a mismatch between the expectations of the British National Curriculum and what their primary teachers know and understand about topics such as *The Earth's place in the universe*. They contend that developing teachers' understanding of Earth and Space sciences through in-service training would be a formidable task, as these phenomena are complex, and real understanding would involve crucial considerations of the scale of the solar system and complex motions in three dimensions of three dimensional-bodies. They ask the question if this is an area in which a science specialist would be needed (compare 4.9.1; 4.9.3 and par 5.10.2: Results for specific research problems 1 and 10).

4.6.4.2 Indigenous science content versus Western scientific thought

In Africa, one of the challenges facing teachers is to deal with indigenous knowledge and science in a situation where the national curriculum is firmly based on Western scientific thought. All people are born into environments within which they come to learn their cultural ways of knowing and doing - many of these cultural beliefs and practices reflect remarkable discoveries and technologies. In many cases, indigenous ways of knowing have been misunderstood, overlooked and marginalised as a result of colonialism and global trends. Nowadays, early indigenous knowledge of the environment was taken on board and reshaped within the developing sciences. People have a natural curiosity and a strong desire to understand their surrounding world. Teachers should encourage this curiosity and take note of this desire for understanding in the learners they teach. Teachers also need to learn to feel comfortable with the good aspects of local cultural beliefs as well as scientific knowledge, and this attitude should be passed on to the learners. Interaction between cultures provide opportunities for a new kind of science - to a new way of knowing and seeing things, where differences and similarities are noted, where new questions arise which may lead to new hypotheses, better predictions and experiments to explore new solutions.

Learning success in science can be attained if local and scientific knowledge complement each other (O'Donoghue 2004:180-190). In the RNCS, 30% of the content must be selected from local contexts (economic, environmental, social or health contexts which are significant to the learners and the local community). In this way, the scientific investigation can draw from many sources and in doing so, make the Natural Science learning more relevant and interesting.

4.6.5 The place of the Natural Sciences in the Foundation Phase

The *Numeracy*, *Literacy* and *Life Skills Learning Programmes* for the Foundation Phase aim to provide for the holistic development of learners. These three Learning Programmes have as their backbone the development of concepts and skills described in the Learning Outcomes from the *Mathematics, Languages and Life Orientation Learning Areas* respectively. All the Learning Outcomes as well as their Assessment Standards from *all* the other Learning Areas must be addressed within these three Learning Programmes. Teachers have to plan *where* the additional Learning Outcomes should be integrated, but also ensure that the integration is meaningful and well planned. The three Learning Programmes should be seen as related and reinforcing one another. Through these Learning Programmes, holistic development and preparation for the Intermediate Phase are envisaged (DoE 2003:27-29).

The Natural Science Learning Area should accordingly be presented in an integrated way in the Numeracy, Literacy or Life Skills Learning Programmes in the Foundation Phase. While the Learning Outcomes of the Mathematics, Languages and Life Orientation Learning Areas are taken as the *core* Learning Outcomes, the Natural Science Learning Outcome is to be integrated as an *additional Learning Outcome*.

From informal interviews with DoE and GDE officials, there seems to be confusion surrounding the *place* of the Natural Sciences Learning Area in the RNCS. In some instances, people (including lecturers and teachers) believe that the Learning Areas such as Natural Sciences, Social Sciences, Economics and Management Sciences, Technology and Arts and Culture, form part of the *Life Skills Learning Programme*. In other cases, these Learning Areas are believed to be part of all three the Learning Programmes and are then integrated into any of the three Learning Programmes, whenever possibilities for meaningful integration present themselves. The origin of this confusion is difficult to establish. It is however a misunderstanding, apparently more prevalent among educators in the Gauteng districts, that needs to be addressed.

The perceptions of teachers regarding this issue were tested as part of the empirical survey (see par. 5.19.2: Results for specific research question 7).

4.6.6 Time allocation and weighting for Learning Areas in the Foundation Phase

Teachers need to be aware of the time allocations and weightings allocated to Learning Areas to be able to develop their learning programmes (DoE 2003:6). The RNCS details the time that should be allocated to each Learning Area in the Intermediate and Senior Phases. In the Foundation Phase, however, times are only allocated to *Learning Programmes*. No time or weightings are allocated to Learning Areas individually (as the remaining Learning Areas are only supposed to be taught in an integrated way).

Formal teaching time for learners in the Foundation Phase as set out by the DoE (2003:31-32) is presented in TABLE 14 (below):

TABLE 14

Time allocations for the three Learning Programmes in the Foundation Phase			
Learning Programme	**Literacy**	**Numeracy**	**Life Skills**
Grade R, 1, 2 and 3	40%	35%	25%
Grade R, 1 & 2	Formal Teaching time: 22 hrs 30 min per week		
Time per week	9 hrs 10 min	7 hrs 30 min	5 hrs 50 min
Grade 3	Formal Teaching time: 25 hrs per week		
Time per week	10 hrs	8 hrs 45 min	6 hrs 15 min

The *Teacher's Guide for the development of learning programmes* makes recommendations for teachers with respect to how Learning Outcomes should be weighed in relation to each other (DoE 2003:5). In this context then, the assumption can be made that the *Learning Outcomes* of a Learning Area largely determine the weighting (importance and value) of such a Learning Area. In the case of the NSLA, only *one* Learning Outcome is proposed for the Foundation Phase.

It is important to mention some of the time allocations in the Intermediate and Senior Phases (DoE(a) 2002:18). See TABLE 15:

TABLE 15

Foundation Phase Learning Programme		Intermediate and Senior Phase Learning Area	
Literacy	40% →	Languages	25%
Numeracy	35% →	Mathematics	18%
Life Skills	25% →	Life Orientation	8%
Natural Science	**integrated** →	**Natural Science**	**13%**

It is clear that a large proportion of time in the Foundation Phase is spent on building a solid foundation for Learning Areas such as Languages and Mathematics. The NSLA constitutes the third largest part of the formal teaching time in the Intermediate and Senior Phases. It therefore seems very important that a solid foundation for Natural Science should also be established in the Foundation Phase, to be built on throughout life.

The high value placed on science and scientific literacy should be reflected by the place of science in the Foundation Phase curriculum and should be taught on a regular basis (Goodrum, Hackling and Rennie 2001). It is a difficult task to determine the actual time (in hours and minutes) that should be spent by every teacher on a specific Learning Area taught in an integrated way. The frequency of integration and time spent on Natural Science depend to a large extent on the individual teacher's attitude towards Natural Science in general, and on the value she attaches to the teaching of science.

4.6.7 Integration of the Natural Science Learning Area with other Learning Areas

Fleer and Hardy (2001:56) note that science typically receives little space in the school timetable. This is also the case in the South African Foundation Phase. However, when science is taught in conjunction with other Key Learning Areas (KLA's), larger time allocation to science topics is possible (*KLAs = refer to *Key Learning Areas* in the Australian Curriculum which corresponds to *Learning Areas* in the South African context.)

Linking science to other KLA's can be achieved in two possible ways :

- science operates as a vehicle for the topic (e.g. the sun), and the teaching and learning in science is supported in other lessons in other KLAs; and
- the topic can be focused in other KLAs (e.g colour in art), and then supported by science (experiments involving colour).

It seems worthwhile to consider some possible links between the NSLA and the other Learning Areas. In the South African context, however, the NSLA only have three linkage possibilities, namely to the Languages, Mathematics and Life Orientation Learning Areas (not to the seven remaining Learning Areas of the RNCS).

4.6.7.1 Linking possibilities with the Literacy Learning Programme

While some teachers may avoid the teaching of Natural Science, many teachers are very enthusiastic about teaching science and want to successfully integrate science in other Learning Areas. In many schools, teachers are required to focus on Language and Mathematics Learning Areas as these are seen as the main focus of primary education. But many good reasons exist for integrating science in other Learning Areas, and there are strategies to successfully use interdisciplinary instruction.

According to Akerson (2001:43), there are many important reasons for interdisciplinary instruction, and specifically for integrating science in the *language arts*:

- learning science is often described as a process similar to learning language: from questioning and setting a purpose to analysing and drawing conclusions and reporting or communicating results;
- young learners need to read, write, and communicate about something - science can provide that purpose; and
- the most pragmatic response may be that science achievement will soon be tested as well (as already happening in Languages and Mathematics Learning Areas). If priority is not given to science instruction, science will start at a disadvantage. It therefore makes sense to support science learning and use science as a purpose for language instruction and at the same time prepare learners for the tests they may take.

In the RNCS, the Learning Outcomes from the *Language Learning Area* form the backbone of the Literacy Learning Area. The Language Learning Area contributes to the curriculum and links to Natural Science as it

- develops reading and writing, the foundation for other important literacies, including scientific literacy;
- is a medium for learning;
- provides a way of communicating information, and promotes many of the goals of science, technology and environmental education; and
- develops critical tools necessary to become responsible adults (DoE/GIED 2002:19-21).

Core outcomes from Languages that can be linked to Natural Science:

- Learning Outcomes 1-4 cover the language skills - listening, speaking, reading, viewing and writing;
- Learning Outcome 5: (Thinking and reasoning) deals with the uses of languages for thinking and reasoning, which is especially important for the language of learning and teaching as the learner will be able to use language to think and reason, process and use information for learning (DoE/GIED 2002:19-21).

A central principle of the Languages Learning Area Statement, is the integration of all aspects of language through the creation and interpretation of texts. In this way, the Literacy Learning Outcomes (Reading and Writing, Listening and Speaking, Thinking and Reasoning, and Language Structure and Use) provide links between Literacy and other Learning Programmes, including the NSLA. In the latter, for instance, learners could read and view a Natural Science related picture book (DoE 2003:47).

As part of the integration through texts, integration can take place by means of themes, some of which would relate to science. Themes should be carefully selected to stimulate the interests of both boys and girls from different environments, for example, rural and city schools. Themes should also be relevant to their lives and be chosen with the Critical and Developmental Outcomes in mind (DoE 2003:47). Meaningful themes promote the discussion of big ideas and offer a greater likelihood that science outcomes can be met. Themes such as systems, models, constancy and change enable teachers and learners to explore a wide variety of science concepts. Language outcomes can be incorporated in the same way as in the study of less scientific themes (Akerson 2001;43).

It is clear that the Languages Learning Area provides many opportunities for meaningful integration of science. Science learning involves the constant use of language. The classroom setting should therefore allow frequent opportunities for learners to talk about their ideas of science with peers and the teacher. When children report their findings orally or in writing, they develop skills in communication. Children's books with science as a theme, provide another link. This reading matter can also provide a context for science activities (Fleer and Hardy 2001:58).

4.6.7.2 Linking possibilities with the Numeracy Learning Programme

The Learning Outcomes from the *Mathematics Learning Area* form the backbone of the Numeracy Learning Area. The Learning Outcomes of Mathematics include a broad basis of numbers, operations and relationships, patterns, shape and space, measurement, and data handling. Numeracy, therefore, helps people to describe situations by numbers, symbols and/or with drawings and graphs. While the Numeracy Learning Programme has at its backbone the Mathematics Learning Outcomes and their relates Assessment Standards, the Learning Programme is drawn from all eight Learning Areas. The Learning Outcome of the NSLA should therefore also be integrated into the Numeracy Learning programme. Mathematical tools, for instance, can help people to describe and analyse natural occurrences such as patterns and shapes of plants, rock formations, the weather and the movement of the planets (DoE 2003:57,58).

In early childhood education, mathematics and science are interrelated. The fundamental concepts such as comparing, classifying, and measuring are simply called *process skills* when applied to science problems. Fundamental math concepts are needed to solve problems in science, while the other science process skills are equally important in solving problems in both science and mathematics (Charlesworth and Lindt 2003:4). Many opportunities exist for using science activities to learn and practice mathematical understanding and skills (Fleer and Hardy 2001:58).

4.6.7.3 Linking possibilities with the Life Skills Learning Programme

The *Life Orientation Learning Area* provides the backbone for the Life Skills Learning Programme. The Learning Outcomes for Life Orientation are used as main foci, with related additional Learning Outcomes and Assessment Standards from all the other Learning Areas fully integrated (DoE 2003:75). As the Life Skills Learning Programme aims to develop knowledge, skills, values and attitudes that will enable learners to identify and solve problems, and to make decisions, it is clear that the knowledge, skills, values and attitudes learned through the Natural Sciences can easily be integrated into the Life Skills Learning Programme.

The GDE/UNISA (2003 (3):4), defines *Life Skills* as the skills that:

- help us to understand ourselves, the world and our place in it;
- are essential to make life easier and increase the possibility of realising our potential and become productively involved in the community; and
- enable us to translate knowledge, attitudes and values into action. "It guides us to know what to do, how to do it and when it is appropriate to do something."

The Life Skills Learning Programme deals with the full range of life skills that empower learners to:

- develop their full potential physically, emotionally, socially, intellectually and normatively;
- participate effectively within their environment and develop scientific and technological process skills;
- become empowered citizens and to prepare them for the world of work; and
- be creative thinkers/citizens (GDE/UNISA(3) 2003:4).

The Life Skills Learning Programme takes up a large proportion of time (25%) in the Foundation Phase. This programme offers all South Africa's young children the opportunity to develop the capacity to participate in the life of South African society in meaningful ways (DoE 2003:73). Although LO1 of NSLA must be presented in an integrated way in the Life Skills Learning Programme, it is important to develop Natural Science knowledge, skills, values and attitudes in meaningful ways in this programme in order to contribute to the full personal development of all Foundation Phase learners. The promotion of scientific literacy in this programme is also important to prepare learners for social and economic development, to help them make sense of their surrounding world (and to solve real life problems, using their science knowledge and skills), and to prepare them to make skilled and informed life decisions.

4.6.7.4 Conclusions

Although LO1 of NSLA receives little prominence in the RNCS and the NSLA is not regarded as a core Learning Area, there are adequate opportunities for the NSLA to be integrated into all three Learning Programmes. However, successful implementation will depend on the individual Foundation Phase teacher, her training and the support she receives in the school and provincial context. There is an urgent need to lay a solid foundation for developing scientific knowledge and understanding in the Foundation Phase. Whether the integration of the single Learning Outcome places enough emphasis on the value of Natural Science teaching in terms of its place, time allocation and method of teaching, seems reason for concern.

4.7 THE TEACHER AS CURRICULUM IMPLEMENTER

Children's first encounters with science as a subject may have a long-term impact on their interest in and attitudes to science, and have the potential to provide a useful basis of science knowledge, understanding and skills. Although there is considerable variation between countries in terms of curriculum content and emphasis, reflecting local and national traditions, aims and priorities, in all countries *teachers* are the key to realising these curriculum aims. The quality of the science education which learners receive, depends ultimately on the teachers (Asoko 2000:79). The NSLA aims at developing *scientific literacy* among learners. Becoming scientifically literate requires more than just knowing content (Goodrum, Hackling and Rennie 2001). There is an increasing emphasis on teachers' knowledge and understanding of science to be able to teach science effectively and helping learners to become scientifically literate.

4.7.1 How much science does the teacher need to know?

As seen earlier, there is the misconception that content is the main focus of Natural Science teaching, and that facts, concepts, theories and bits of information need to be communicated to learners. While Natural Science teaching consists of more than mere content, the question regarding the amount of science content commanded by Foundation Phase teachers remains important.

A wide background knowledge of the discipline is indeed obligatory to effective science education. Foundation Phase teachers should at least know the basics of science, the fundamental facts and concepts in major science disciplines. Suitable and adequate teacher educational materials are therefore crucial, especially to teachers lacking a basic science education background.

Recent science education literature increasingly advocates the adoption of a constructivist approach to the learning of science. A key feature of this approach is acknowledging the fact that individuals are likely to bring along various *misconceptions* to any learning situations. In a study undertaken by Summers and Mant (1995:13), it was found that primary teachers themselves are likely to bring *misconceptions* into the classroom when dealing with topics that they are not knowledgeable about, for instance topics from Earth and Space sciences.

Foundation Phase teachers face at least three difficulties in knowing enough science content (Martin 2003:7):

- the amount of science known today is enormous - too large for any person to be able to know even a small part of it;
- scientific knowledge may become obsolete in future. What is known today may be replaced with different information in a few years time; and
- scientific knowledge changes over time. Scientific enquiry often results in the rejection of a previously accepted theory and replaced by another.

The question of how much science the Foundation Phase teacher needs to know is therefore difficult to answer. In the USA, The National Science Education Standards suggest that teachers of science must have a strong, broad base of scientific knowledge extensive enough for them to:

- understand the nature of scientific enquiry, its central role in science, and how to use the skills and processes of scientific enquiry;
- understand the fundamental facts and concepts in major science disciplines;
- be able to make conceptual connections within and across science disciplines as well as mathematics, technologies, and other school subjects;
- use scientific enquiry and ability when dealing with personal and societal issues (National Research Council 1996, in Martin 2003:8-9).

Competent teachers know a great deal more than the subject matter they teach. For effective teaching of science, teachers also need to take account of how children learn. Goodrum, Hackling and Rennie (2001) refer to research done by Darling-Hammond (1997) who pointed out that “teacher knowledge of subject matter, student learning and development, and teaching methods are all important elements of teacher effectiveness”.

He also contradicts the long-standing myths that "anyone can teach" and that "teachers are born and not made". Considerable thought and experience on the part of the science teacher are required to teach science effectively. Careful planning which amalgamates knowledge of the subject and knowledge of the learner is therefore crucial. To develop quality pedagogical content knowledge takes time and experience. A good science teacher is therefore not born, but made.

4.7.2 Factors inhibiting the quality of science teaching

4.7.2.1 School-based support

Collegial support in the form of collaborative teacher planning, incidental help offered by a colleague, networks of interested teachers, and sharing of ideas are factors that can positively influence the teaching of science in schools. Such support can provide ideas for teaching, increase self-confidence and provide motivation to try new things and generate self-reflection (Appleton and Kindt 1999:159). In the Science Report of the Department of Education, Training and Youth Affairs (DETAYA), teachers mentioned a lack of time and opportunity to share ideas, collaborate, reflect, evaluate, adequately prepare and participate in professional development. In many schools, difficulties in the provision of leadership and mentoring in terms of curriculum developments and whole school strategies were also identified as inhibitors of teaching science (Goodrum, Hackling and Rennie 2001).

4.7.2.2 Teacher self-confidence

Lack of self-confidence of primary and early childhood teachers has often been identified as a factor working against the teaching of science. Appleton and Kindt (1999:163) pointed out that a lack of confidence influences whether science is taught or not. A lack of confidence also impinges on the topics teachers choose and the strategies they employ. Other studies reveal that teachers tend to believe that hands-on strategies should be used in teaching science, but seldom use them (Jeans and Farnsworth in Appleton and Kindt 1999:163). The reason why teachers tend to focus on teaching scientific vocabulary and facts, while avoiding causal explanations and teaching for understanding, could be because teachers lack confidence in science to explain or draw out explanations from the learners. They may therefore rather play safe, filling children with facts, and avoid the reasons (Newton in Wenham 2005: xv-xvi).

4.7.2.3 Low priority for science

Science in primary and early childhood settings is often given a low priority by teachers. Teachers also often view science as more appropriate for secondary learners and consider the three R's (reading, writing and arithmetic) as the main focus for primary school. Although this is often held as a personal view, it is reinforced by the system - for instance the inadequate time allocation to science. In Australia, the low perceived priority resulted in a tendency to allocate times for science when learning demands are seen as less strenuous (e.g. afternoons); science was often the subject to be dropped where time pressures arose from extra-curricular activities (Appleton and Kindt 1999:165). Even in the UK, where science is regarded as a core curriculum subject, it is rarely afforded equal status with language and mathematics (Newton in Wenham 2005:xv). An overcrowded school curriculum was also indicated as an inhibitor of teaching science (Goodrum, Hackling and Rennie 2001).

4.7.2.4 Unavailability of resources and large classes

In the DETAYA Science Report, teachers agreed that poor resourcing is a major constraint to quality teaching and learning in Natural Science. Too large classes make it difficult to pursue quality practical work, and limit the teacher's ability to focus on individual learning opportunities (Goodrum, Hackling and Rennie 2001). In the study of Appleton and Kindt (1999:162), teachers indicated a lack of resources as an important factor influencing their teaching of science. Unavailability of resources could result in a topic being avoided; it could determine how a topic is taught and also determine the actual activities the learners engage in. If available resources are poorly organised in a school, they become effectively unusable. Teachers committed to teaching science often have to go out of their way to obtain resources for science lessons. In many instances, teachers would rather decide not to teach science than to invest extra time, organisation and cost in obtaining the needed science resources.

According to Newton (in Wenham 2005:xvi), two approaches to improving science teaching are possible. In the first approach, teachers should be provided with suitable materials and trained to use them appropriately and to the point. According to this model, what teachers do not know, does not matter. However, this factory model of teaching ignores the human element of both teacher and learners. Even the most perfect teaching materials can be bent to the teacher's particular conceptions of science - and this, in turn, will shape children's conceptions.

It also does not allow for the infinite variety of unexpected questions. The teacher will very quickly once again have to draw on her own resources. The point? Knowledge of the subject is indispensable. The alternative approach is to assist teachers in the construction of worthwhile lessons that will suit the needs of the learners in their class. Teachers will still need to know enough science to produce and tune lessons to the needs of their learners and to help learners construct scientific explanations. A danger of such "official" schemes is that development and creativity in science lessons are stifled. The ability to produce effective science lessons needs a teacher who does not follow blindly the plans of others. The teacher needs to know the essence of a subject and needs to understand the science she is teaching.

4.7.2.5 Teacher training

Teacher education is most important to the quality of the relationship between teaching and learning. In primary schools in Australia, many teachers blamed their lack of firm understanding of scientific principles on poor teacher training. Very few teachers experienced science as a programme (Goodrum, Hackling and Rennie 2001).

In the UK (as in most other countries), preparation to teach science is a compulsory part of initial teacher training courses. According to Newton (in Wenham 2005:xvii), these courses are generally too short to cover the breadth of science, and teachers are then expected to draw upon and develop their own subject knowledge to a significant extent. However, as noted earlier, teachers' own prior knowledge of science, can lack breadth as well as depth.

4.7.3 The science teacher: specialist or generalist?

In most countries, primary teachers (as are Foundation Phase teachers in South Africa) are *generalists*, teaching all Learning Areas. Many teachers find their understanding of science challenged by the demands of the curriculum which they are required to teach. Teachers' lack of subject knowledge in science has been documented and frequently identified as a barrier to implementation of curriculum reform and pupil progress. Teachers who lack content knowledge and confidence often attempt to minimise their difficulties through avoidance of topics in science, heavy reliance on texts, and overemphasis on practical activity. These strategies may result in an impoverished science education for children (Asoko 2000:79).

Is there then a “better kind of teacher” to teach science in the Primary school? The debate about whether to have specialist or generalist teachers has been active for many years, but one that cannot easily be solved (Hobden 2000:88). According to Hobden, the right kind of teacher is “the one who is most able to take the child form the level at which he understands the world to something closer to the latest understanding of the adult scientific community” (2000:81). It is thus clear that the best teacher is the one who knows how children learn best, but also knows science.

It is the opinion of the researcher that a *specialist science teacher* in the Foundation Phase in the South African context would not be a viable option (in terms of practical implementation, funding, etc.). Hobden (2000:90) provides the option of a *semi-specialist* where a specialist would teach some aspects of science collaborating with the regular class teacher. Where general Foundation Phase teachers lack confidence to teach certain areas of the science curriculum, a semi-specialist could be an option. Finding the right kind of teacher for science depends on factors such as the school and its organisation, the curriculum requirements, developments in the science world, political influences and the needs of the learners. In South Africa, the change from the traditional curriculum to C2005, again revised in the RNCS, has placed considerable demands on the teacher in many ways. It therefore seems fair to say that Foundation Phase teachers as generalists need to receive specialised training and support to be able to contribute to high standards in Natural Science education. Sustained improvement of Natural Science will depend on improved teacher capability. This has implications for both initial and in-service teacher training.

4.8 CONCLUSION

The purpose of Chapter 4 was to explore the Natural Science Learning Area in the Foundation Phase as formulated in current policy documents. In this chapter, science education in an outcomes-based paradigm was explained. An overview of curriculum developments in Natural Science education in four countries was presented. Finally, a few challenges facing the generalist teacher in teaching Natural Science were briefly mentioned.

In Chapter 5, the current state of Natural Science education in the Foundation Phase will be surveyed by means of a questionnaire.

CHAPTER 5

PERCEPTIONS OF NATURAL SCIENCE TEACHING: A SURVEY

5.1 INTRODUCTION

The first part of this study (Chapters 2, 3, and 4) consisted of an extensive review of the relevant literature on Natural Science education for young learners. In Chapter 2, an inclusive view was offered of the scope of science in general, and of Natural Science at the Foundation Phase in particular. Chapter 3 reviewed influential perspectives on learning and focussed on issues relating to Natural Science learning and teaching. In Chapter 4, the Natural Science Learning Area in the Revised National Curriculum Statement was explored extensively. Curriculum developments internationally as well as in the African context were also addressed.

The second part of the study (Chapter 5) presents the findings of an empirical survey into the perceptions (attitudes and understanding) of South African Foundation Phase teachers (in a limited geographical area) with regard to Natural Science education at this level. The structure of the chapter is as follows. In the first section, the research design for the investigation is discussed. The steps taken by the researcher to address the research questions are described, and a number of specific research problems are stated. Various aspects of the investigative format are consequently put on the table, including the chosen research design, population, the questionnaire as research instrument, and the analytical methods employed.

In the second section of the chapter, the results of the survey are presented. As the data obtained from the survey cannot be discussed exhaustively in the present format, the discussion remains restricted to the main aims of the study. Consequently, the various clusters are treated by means of, and in relation to, the identified specific research problems.

Two more technical aspects of the survey are included in the data analysis section, as received from the *Research Support Unit* of the *UNISA Computer Services Department.* First, item analysis and the Cronbach alpha coefficient test were conducted to establish item reliability (see par. 5.10.3.1).

Secondly, analysis of variance and Bronferroni multiple comparison of means test were also conducted on the data, mainly to establish relationships between biographical data and the various item results (5.10.3.2). While these lie on the periphery of the current investigation, the results obtained are nonetheless presented and briefly discussed.

5.2 THE PURPOSE OF THE EMPIRICAL RESEARCH

The purpose of this empirical survey is to explore the current situation regarding Natural Science education in the South African Foundation Phase from a selected population and to make recommendations.

5.2.1 General problem statement and research hypothesis

As stated in Chapter 1, the research problem is formulated as follows:

> Does the current situation in South African schools provide a solid basis for Natural Science in the Foundation Phase on which learners can build throughout life?

This problem is linked to the hypothesis, formulated as follows:

> The current situation regarding science education in the Foundation Phase does not establish a solid basis on which learners can build.

This hypothesis is to be tested against the results of the empirical survey, to establish whether it is supported by the evidence or not.

5.2.2 Specific research problems

The following are specific research problem statements flowing from the main problem statement, and breaking up this problem into more manageable and quantifiable subsections in order to direct the empirical research.

The specific research problems were identified during the literature review. It became evident from the presented literature that numerous variables may play a role in the current state of Natural Science education in the Foundation Phase. The literature review suggested that these variables may be connected to some specific problems. These are the problems that need to be investigated and addressed before recommendations to improve the situation can be made.

The specific research problems are stated as follows:

Specific research problem 1
Are past personal experiences of teachers with science predominantly positive or negative?

Specific research problem 2
Do teachers feel confident about their abilities to teach Natural Science?

Specific research problem 3
What are teachers' views and understandings of the nature of science?

Specific research problem 4
What are teachers' perceptions of the abilities of Foundation Phase learners to learn Natural Science?

Specific research problem 5
What are teachers' perceptions regarding appropriate methods for Natural Science instruction?

Specific research problem 6
Do teachers view Natural Science as a priority in the Foundation Phase curriculum?

Specific research problem 7
Do teachers understand the place (integration) of the Natural Science Learning Area in the Foundation Phase curriculum?

Specific research problem 8
Are teachers aware of the *number* and *meaning* of the Learning Outcomes for the Foundation Phase?

Specific research problem 9
Do teachers understand and use the process skills in their science teaching as set out in the Natural Science Learning Area Statement?

Specific research problem 10
Do teachers feel competent to select developmentally appropriate science content?

Specific research problem 11
Are teachers appropriately trained to implement the Natural Science Learning Area in practice?

Specific research problem 12
What actual time is spent on Natural Science teaching in the Foundation Phase?

Specific research problem 13
Which factors inhibit the teaching of Natural Science in the Foundation Phase?

5.3 THE RESEARCH DESIGN

The research design is a detailed plan of how the study is to be conducted. Huysamen explains the purpose of the research design by specifying that "this plan offers the framework according to which data are to be collected to investigate the research hypothesis or question in the most economical way" (Huysamen 1993, as quoted by Fouché and De Vos 1998:124).

The research method used in this part of the study is an empirical investigation. The investigation follows a non-experimental research design; more specifically, the method followed has the characteristics of a *descriptive survey*. This form of survey aims at describing the *incidence, frequency, and distribution of certain characteristics of a population* (Leedy 1997:111). Applied to the study at hand, the survey aims at observing and presenting evidence regarding the current state of Natural Science education in the Foundation Phase from a selected population. The sample population is constituted from practising Foundation Phase teachers in a delimited geographical area. The data gathered by means of the survey are consequently "organized and presented systematically so that valid and accurate conclusions can be drawn from them" (Leedy 1997:191).

5.4 RESPONDENTS/POPULATION

The survey was conducted among Foundation Phase teachers (Grade R, 1, 2, and 3) in a delimited geographical area: a selection of primary schools of the Tshwane-North and Tshwane-South districts of the Gauteng Department of Education. Due to constraints of time and costs, schools within the proximity of the researcher were included in the survey, so that the sampling method falls under the accepted category of convenience sampling. The schools included in the sample were selected from typical urban and suburban institutions in order to enhance representivity of the population at large (e.g. inner-city, sub-urban, private and special schools). Since schools participated on a voluntary basis, the weighting of the schools included in the final sample leans towards the so-called ex-Model C schools (previously advantaged schools).

It must furthermore be noted that a number of questionnaires distributed among teachers from the so-called historically disadvantaged schools were not included in the final data analysis, due to poor quality of response (see par. 5.8 *Shortcoming ...*). The special schools that were approached, indicated that they do not teach Natural Science as a Learning Area due to the intellectual barriers of the learners in their Foundation Phase classes, and were therefore not included in the sample. While the survey consequently cannot claim to be fully representative of the larger population (all Foundation Phase teachers in South Africa), it is surmised that the results gained are sufficient to indicate trends with regard to the population as a whole. As such, a limited survey is regarded as sufficient for the present study.

5.5 INSTRUMENT

The technique used for observing data for this survey, is the questionnaire. An example of the full questionnaire used in this study, is included in Appendix C.

The following aspects are important regarding the questionnaire as a research instrument:

5.5.1 The questionnaire as a tool for data collection

Fouché (1998:155) states that "the basic objective of a questionnaire is to obtain facts and opinions about a phenomenon from people who are informed on the particular issue". The questionnaire as instrument aims at observing data within the minds, attitudes, feelings or reactions of people beyond the physical reach of the researcher (Leedy 1997:191). In the context of the present study, the questionnaire may be viewed as the most appropriate tool for obtaining information about the attitudes and understanding of practising Foundation Phase teachers regarding Natural Science teaching.

Having presented a case for the choice of a questionnaire, it is important to consider the particular type of questionnaire used in the present study.

5.5.2 Type of questionnaire

- **Questionnaire delivered by hand**

The questionnaires were distributed among Foundation Phase teachers in primary schools from the greater Pretoria area. They were delivered by hand by the researcher, aided by 4th year students in B Ed (ECD/Foundation Phase) of the University of Pretoria, doing their practical teaching. The researcher was also aided by a GDE-official who distributed questionnaires in historically disadvantaged schools. In this way, respondents could complete them in their own time, while time was saved and response rates were raised (Fouché 1998:155). Appointments were made for collecting the questionnaires, approximately seven days after delivery, on a date that suited both parties. Questionnaires were distributed during August and September 2005.

Questionnaires were also administered at two workshops for practising teachers: one held at University of South Africa, and another at a workshop for under-qualified Foundation Phase teachers from the Mamelodi and Hammanskraal region.

- **Items**

Rating-scale and closed form (e.g. yes/no) items are used in the questionnaire design, in order to promote effective quantification and facilitate data analysis. A few open questions were included to enable the researcher to better explore the variables (Fouché 1998:160).

5.5.3 Focus of the items in the questionnaire

The items are spread as follows:

Section A: biographic and demographic information (Questions A1-7) is gathered with the view to obtaining the following:

- the age of the respondent
- highest academic and professional qualifications
- years experience as teacher in the Foundation Phase
- the grade the teacher is currently teaching
- type of school
- language of instruction.

In **Section B**, questions were structured to probe the current situation regarding Natural Science education in the Foundation Phase. The development of these items had their basis in the literature study of Chapters 2, 3 and 4. The specific research questions are directly related to the items in this section. Questions were clustered to gain information and insights under the following headings:

(Cluster 1: Questions B1-B12) Past personal experiences regarding science.

From these questions, the respondents were required to indicate their own past personal experiences regarding science on a 5-point scale. The aim with this section was to establish their attitudes (mainly positive or negative) towards science in general as a result of their own experiences with the subject.

(Cluster 2: B13-B19) Confidence regarding the presentation of Natural Science.

From these questions, teachers were required to indicate their attitudes towards presenting Natural Science as a Learning Area on a 5-point scale. The aim with this section was to establish their attitude towards, but specifically their confidence to present Natural Science in their classrooms. This was included because a lack of confidence in teachers has been identified as a factor working against the teaching of science. A lack of confidence influences whether science is taught or not and impacts on the topics teachers choose and the strategies they employ (see 4.7.2.2).

(Cluster 3: B20-B23) Teachers' views of the nature of science.

The aim of this section was to establish teachers' understanding of the nature of science in general and at Foundation Phase level specifically. Teachers' clear understanding and knowledge of the nature and dimensions of science are assumed to influence the effectiveness of their science teaching.

(Cluster 4: B24-B27) Teachers' views of the abilities of Foundation Phase learners to learn science.

The aim with these questions was to explore whether teachers regard all Foundation Phase learners capable of doing science.

(Cluster 5: B28-B44) Teachers' views of appropriate methods of teaching Natural Science.

Teachers' understanding of how Foundation Phase learners learn best and how science is taught best, is crucial for effective science education. Teachers were required to indicate their skills and preferred methods regarding science instruction.

(Cluster 6: B45-B54) Teachers' views of the importance of Natural Science in the Foundation Phase.

Natural Science in primary settings is often presumed to be given a low priority by teachers. The assumption is that teachers would view science as more appropriate for older learners and that they would consider the three R's (reading, writing and arithmetic) as the main focus for primary school teaching. The aim of this cluster was to establish whether teachers view science as a prominent part of the Foundation Phase curriculum or whether they feel that the main focus should be on the teaching of language, mathematics and life orientation.

The following clusters deal specifically with teachers' perceptions and understanding of aspects related to the Natural Science Learning Area Statement.

(Cluster 7: B55-B64) Teachers' understanding of the place of the Natural Science Learning Area in the Foundation Phase (and integration).

The aim is to establish whether teachers understand that the Natural Science Learning Area should be taught across all three Learning Areas where natural integration possibilities exist, and whether they feel that scientific literacy can be promoted by teaching Natural Science in an integrated way.

(Cluster 8: B65-B75) Teachers' understanding of the Learning Outcome for the Natural Science Learning Area.

As the promotion of scientific literacy depends on teachers' sound knowledge and understanding of the subject area, teachers were required to indicate their understanding of the Learning Outcome for Natural Science by indicating their choice on a 5-point scale. Through these items, their understanding of the *number* of LO's for the Foundation Phase as well as the *meaning* of the Learning Outcome for Natural Science was observed. Countercheck items were also included in this section.

(Cluster 9: B76-84) Teachers' understanding and use of the process skills.

The process skills is central to Natural Science education. Because the Foundation Phase teacher must be able to facilitate the process of scientific enquiry effectively, this cluster deals specifically with the process skills as set out in the Natural Science Learning Area document. Teachers were required to indicate their understanding and use of the process skills. Questions B83 and B84 were included as countercheck items. An open question (Section C) was also included to enable the researcher to explore this aspect better.

(Cluster 10: B85-B94) Teacher's perceptions regarding the selection of suitable content.

The overall aim of the Natural Science curriculum is the promotion of scientific literacy. It is therefore important to ensure that primary science lays the foundation of knowledge across a range of ideas from all the content areas. This cluster explored ways in which suitable content is selected to cover the broad spectrum of core knowledge and concepts as set out in the Natural Science Learning Area document. Teachers' preferences regarding content areas were also explored.

(Cluster 11: B95-B111) Pre-service and in-service training.

The quality of Natural Science education received by learners ultimately depends on the quality of teacher education. This cluster aimed at establishing what training (both pre-service and in-service) and support teachers receive regarding Natural Science education at school and district level.

(Cluster 12: B112-B115) Frequency of integration.

In this cluster, teachers were required to indicate how often they integrate Natural Science in one of the Learning Programmes. An open question (Section C) was also included for teachers to indicate the actual time (in hours and minutes) spent on Natural Science teaching in each of the Learning Programmes.

(Cluster 13: B116-123) Inhibitors of science teaching.

Teachers were required to indicate the most important factors inhibiting their teaching of Natural Science. An open question (Section C) prompted teachers to suggest ways in which the teaching of science may be improved.

Section C (C1-C3). Open questions.

Respondents were required to reflect on the situation in their classroom and/or school, for instance, the allocation of formal teaching time (in hours and minutes) per week to Natural Science in each of the Learning Programmes, and the use of process skills. They were also prompted to suggest ways in which the teaching of Natural Science may be improved. These open-ended question were included for the researcher to gain deeper insight into the issues facing teachers teaching Natural Science, and to gather first-hand recommendations from them.

5.5.4 Procedures

Permission for administering the questionnaire among Foundation Phase teachers in the greater Tshwane Metropolitan area, was first requested from the Gauteng Department of Education (GDE). After permission was granted, the researcher selected and contacted schools from the list of schools provided by the GDE in the D3 and D4 districts. Only the schools that indicated their willingness to participate were included in this research.

Two letters accompanied the questionnaires:
(1) The permission letter from the GDE (see Appendix A); and
(2) A letter from the researcher explaining the reasons for the research, describing the potential value, providing instructions and expressing gratitude for participation (see Appendix B).

5.5.5 Pilot testing the questionnaire

The semi-finalised questionnaire was pretested by experts in the field. These included: (1) two colleagues involved in Foundation Phase teaching at different universities and (2) eight Foundation Phase teachers in practice.

The aim of the pilot testing was to:

- establish how long it took to complete the questionnaire;
- establish if any questions were found ambiguous or unclear;
- indicate any shortcomings; and to
- gather suggestions and recommendations with regard to the questionnaire.

After the pilot testing, modifications were made to the questionnaire in order to ensure the success and effectiveness of the instrument. The questionnaires of the pilot study were not included in the research.

5.5.6 Feedback

A total of 230 questionnaires were distributed to various Grade R, 1, 2, and 3 (Foundation Phase) teachers. Of the total, 191 were returned, thus achieving a return rate of 83%. This high percentage of feedback is mainly due to the fact that the questionnaires were delivered and collected by hand at schools where teachers indicated their willingness to participate. It must be noted that missing frequencies occurred due to a number of questionnaires from the so-called historically disadvantaged schools containing unanswered items.

5.6 VALIDITY AND RELIABILITY

Validity refers to the requirement that the questionnaire should measure what it is supposed to (Hopkins:online) and is therefore concerned with the soundness and the effectiveness of the measuring instrument (Leedy 1997:32).

The validity of the questionnaire was ensured by means of the following:

- The questionnaire was pretested by experts in the field (see par 5.5.5), to check whether the questions asked were able to elicit the information sought. Pretesting relates to the validity of the content, or in other words, how accurately the instruments measure the factors under study (Leedy 1997:34).
- The instrument was made relevant to the South African context as it was designed to measure a particular situation, using language that is clear to those expected to respond (Mouton 2001:102; Leedy 1997:192).
- Countercheck questions were incorporated to help verify consistency (Leedy 1997: 193), and as a result, to ensure validity.

Reliability is described by Leedy (1997: 35) as “the consistency with which a measuring instrument performs”. The synonyms *dependability, stability, consistency, predictability, accuracy, reproducibility, repeatability and generalisability* are provided by De Vos and Fouché (1998:85) to clarify the concept. They further maintain that “an instrument is reliable to the extent that independent administrators of it or a comparable instrument consistently yield similar results”. One can therefore draw the inference that the reliability of the measuring instrument enhances the reliability of the obtained information. The reliability of an instrument may be measured by a number of methods. In this study, reliability was checked by means of a computer analysis calculating the Cronbach alpha coefficient, where a value greater than 0.7 ($\bar{x}$ > 0.7) was taken as reliability indicator (see 5.10.3.1).

5.7 BIAS

Bias is inherent to all research. Leedy (1997:220) maintains that it is unprofessional for the researcher to fail to acknowledge the presence of probable bias in the study. As data in the descriptive survey research are particularly susceptible to bias, it is necessary to explain bias and identify possible sources of bias.

Bias can be defined as "conditions or circumstances which affect the external validity of statistical results" (Helberg: online). The following pitfalls of bias can be identified in this study:

(1) *Representative sampling*

In order for the inferences to be valid, the observed sample must be representative of the target population (Helberg:online). In this study, the fact that the final sample is not strictly representative of all Foundation Phase teachers in all nine provinces may constitute a measure of bias in the final result.

(2) *The data collection instrument*

Nukeri (2000:108) acknowledges that the questionnaire as data collection instrument may also be a cause of bias. The ideal format for questionnaires is questions suitable for statistical processing by computer - thus closed form items (Fouché 1998:160). However, questionnaires consisting only of structured and closed items do not allow respondents to freely respond according to their experiences or preferences, but force respondents to choose between predetermined responses. For this reason, the researcher included a section for free responses that were processed manually.

5.8 SHORTCOMINGS AND SOURCES OF ERROR

- Population

The survey is not fully representative of the larger population (all Foundation Phase teachers in South Africa; accurate mapping to various sections of the population, urban as well as rural, etc.). The results therefore only reflect accurately on the situation in advantaged schools approximating ideal circumstances (teachers are appropriately trained, sufficient resources, relatively small classes, etc.).

- Questionnaires delivered by hand

Although response rates are raised, the procedure of delivering questionnaires by hand has distinct limitations, such as that a smaller geographical area can be covered (Fouché 1998:155). This is also the case in this study. Due to lack of time and resources, only schools in the metropolitan area of Tshwane could be covered.

- Language of questionnaires

The questionnaire was made available in English and Afrikaans and was therefore more suitable for teachers teaching in an English and Afrikaans environment. Although questionnaires were also distributed in the Soshanguve, Mamelodi and Hammanskraal-areas, it must be noted that the home languages of these teachers are not English or Afrikaans, which could have influenced the results of the questionnaires. Most of the questionnaires from the Hammanskraal/Mamelodi workshop could not be included due to the poor quality of the responses.

- Limitations and gaps in the data

Not all aspects regarding the Natural Science Learning Area could be observed by means of a questionnaire. Teachers' understanding of the meaning of important concepts such as *scientific literacy* could not be tested.

5.9 ANALYSIS OF DATA

Data has little value before they are transformed into information. The quantitative survey ultimately culminates in the analysis and interpretation of the data to solve the research problems (Mouton 2001:108; Leedy 1997:221). According to De Vos and Fouché (1998:85), data analysis entails “the breaking down of data into constituent parts to obtain answers to research questions and to test research hypotheses” or, as explained by Mouton (2001:108), “breaking up” the data in manageable themes, patterns, trends and relationships. The analysis on its own also does not provide answers to research questions, but must first be interpreted by the researcher. Leedy (1997:221) describes interpretation as “the extraction of meaning form the accumulated data”. Interpretation, then, involves taking the results of the analysis, making inferences pertinent to the research relations studied, and drawing conclusions about these relationships (De Vos and Fouché 1998:203).

5.9.1 Statistical techniques

As has been indicated, the statistical analysis of the quantitative data was performed by the *Research Support Unit* of the *UNISA Computer Services*, using the following statistical techniques: Item analysis and Cronbach alpha coefficient, frequency tables, Chi-square tests; analysis of variance and Bronferroni multiple comparison of means tests. The SAS statistical package, version 9.1 was used to perform all analyses.

5.9.2 Statistical processing

In the following sections, the results of the empirical survey are provided. Firstly, a description of respondents' biographical and demographical data is given (Section A of the questionnaire), followed by the results of the data obtained to test the research problems and hypotheses (Section B of the questionnaire). The results obtained from the open questions (Section C) are treated at the relevant specific research questions, in order to better explore the specific aspect under scrutiny.

The following keys are used in the results:

f	-	the number of respondents that answered a specific item/category
%	-	the number of respondents that selected a certain option, expressed in terms of a percentage.

5.10 RESULTS AND DISCUSSION OF RESULTS

As explained in Chapter 1, the study was motivated by a concern about the state of science education in South Africa, particularly in the Foundation Phase. This section presents discussions of the results obtained through the analysis of the data. Tables, summaries and descriptions of significant aspects are provided in order to facilitate understanding of the information obtained.

5.10.1 Biographical and demographical information

(Please note that missing frequencies occurred, i.e. some items on some of the questionnaires were left unanswered.)

The sample consisted of Foundation Phase teachers, in other words, teachers of Grade R, 1, 2 and 3 learners. The aim of this section was to determine the age and years experience as teacher in the Foundation Phase; the highest teaching qualifications; the grade the teacher is currently teaching; the type of school and the language of instruction (see Questions A1-6) .

The results are as follows:

Qualifications	**f**	**%**
Teacher's Diploma (3years)	33	18.3
Higher/Further Teacher's Diploma	88	48.9
Baccalaureus Degree	30	16.7
Baccalaureus Educationis	15	8.3
Other	14	7.8

Among the "other" qualifications listed by respondents are MEd and Honours degrees, but there were also under-qualified practising teachers with a two year teaching certificate or with matric only.

Age	**f**	**%**
<30	30	16.5
30+	152	83.5

Teachers older than 30 years of age are presumed to have studied before the curriculum transformation took place (in other words before C2005 and RNCS were implemented) and were therefore trained for more traditional teaching. This cannot be regarded as a full proof estimation, since many teachers may have studied later in their lives, either through distance education, or by obtaining a post-graduate teaching qualification. Teachers may also have entered the teaching profession only at a later stage.

Experience	**f**	**%**
<8yrs	54	29.8
8+yrs	127	70.2

It may be presumed that teachers with less that eight years experience had some pre-service training on the new OBE-system implemented in 2000. For many reasons, this is also only a rough estimation.

Grade	f	%
Grade R	29	16.2
Grade 1	53	29.6
Grade 2	47	26.3
Grade 3	50	27.9

Grade R is fully part of the Foundation Phase (Grade R-3) and follows the RNCS, but the teaching approach is of a much more informal nature. Grade R classes are not necessarily part of a primary school, but can be part of a pre-school or playgroup.

Type of school	f	%
state	157	86.3
private	20	11.0
other	5	2.8

It is presumed that all state schools received in-service training on C2005 and the RNCS, and that they continue to receive support from the provincial government in terms of follow-up and curriculum guidelines. Many private schools also use the RNCS, as is the case with those included in this sample. Some respondents who indicated "other" schools did not specify the type of school. It may be assumed that the other category include pre-schools with Grade-R classes and Christian-based schools.

Language	f	%
Afrikaans	107	59.8
English	55	30.7
Other	17	9.5

Other languages are Tswana, and Northern and Southern Sotho, from the historically disadvantaged schools that are included in this sample. Schools from historically disadvantaged areas are evidently not well represented in the sample. The sample is therefore biased towards more advantaged schools.

5.10.2 Results

In section B, respondents were required to indicate their level of agreement with the statements provided, by choosing one of the following options:

1: Strongly disagree
2: Disagree
3: Neutral/Undecided
4: Agree
5: Strongly agree.

For convenient reading, the negative scores *Strongly disagree* and *Disagree* (-) and the positive scores: *Agree* and *Strongly agree* (+) were added together to provide a general indication of the average tendency in a specific item. The *neutral or undecided* option is presented as n/u in the table.

The following keys are used in the discussion of the results:

bb:	-	Represents the cluster under each of the specific research problems (e.g. bb1 = specific research problem 1; bb2 = specific research problem 2; etc)
$\bar{x}$	-	The average score for the results obtained from the 5-point rating-scale items (Standard Deviation). The results obtained for the cluster will be provided at the end of each table of results (Also compare TABLE 17).
-	-	negative
n/u	-	neutral/undecided
+	-	positive

The figures indicated on the tables are percentages (%).

Please note: Results of questions on a 5-point scale are provided in the form of a summary of the average and standard deviation of answers of all the respondents (where appropriate). In order to obtain a more summative impression of how respondents view the main aspects addressed in the questionnaire, a measure of central tendency, (a mean value or score) for each of the clusters were calculated. In this way item reliability was ensured. The mean score ($\bar{x}$) for each aspect (excluding clusters 3 and 4) is provided at the end of each table, but a discussion of these results is only presented in section 5.10.3. (see Tables 1, 1A, 2 and 3).

The results for specific research problems 1-13 are presented below.

- **Results for specific research problem 1** (Cluster 1: bb1)
  Past personal experiences with science: positive or negative?

	-	n/u	+
(B1)I can recall specific positive experiences in science class during High School	19.2	22.0	58.8
(B2) Biology was one of my favourite subjects when in High School	17.2	8.00	74.2
(B3)I had fun with science during Primary School	26.7	32.2	41.1
(B4)I like science	19.74	30.2	49.9
(B5)In general, I feel positive about science	10.4	22.7	66.8
(B6)I find science difficult	37	31.5	31.5
(B7)I view myself as a scientifically literate person	40.9	33.7	25.4
(B8)Science help us deal with our daily problems	9.5	26.0	64.0
(B9)I feel most comfortable with Biological Science (plants, animals, etc)	9.4	16.5	74.2
(B10)I prefer Physical Science (machines, electricity, etc)	59.8	24.6	15.6
(B11)Earth and Space Sciences are my favourite science topics	34.4	32.2	33.3
(B12)When I was at school, girls were encouraged less than boys in science class	39.4	33.3	27.2
bb1: $\bar{x}$ = 3.23 (= 0.55)			

From this table, it emerges that a significant number of teachers who had Natural Science as a subject in high school recall positive experiences (58%); but that more teachers who took Biology as a subject could recall positive experiences (74%). Respondents clearly preferred content from Biological sciences (74%); with 33% choosing Earth and Space sciences and 16% Physical sciences in the order of preference. This corresponds with teachers' preferences regarding the various science content fields, but also with findings in literature that the Life sciences are often preferred (see par. 4.6.4 *The content areas...*; 4.7.1 *How much science ...* and 4.7.2.2 *Teacher self-confidence....*). The term "science" encompasses various sub-fields or content areas. It is therefore difficult to establish whether respondents find science (including all the content fields) difficult, or whether their responses only refer to their preferred sub-field (in this case, mostly the Life sciences). The danger is that these personal preferences may have an influence on their content knowledge, and on the choice of topics and concepts they teach in class. The balance between the four content areas might be disturbed.

With regard to experiences in the primary school phase, the majority of teachers (41%) could recall positive experiences, but a significant 32% were *undecided; this* may probably be due to the fact that little science has been taught in that phase. Nearly a third of the respondents (27%) recalled negative experiences, which can be considered a rather high incidence.

In the case of probable gender-bias, more respondents (39%) indicated that they did not recall any bias during their own school years than those who could recall gender bias (27.2%).

Although the majority of the teachers indicated that they liked science, that they feel generally positive about science, and that they acknowledge science to be an important part of our daily life, a significant number did not view themselves as *scientifically literate* (41%). This raises concern as to whether the respondents are familiar with the meaning of *scientific literacy*.

- **Results for specific research problem 2** (Cluster 2: bb2)
  Confidence with regard to Natural Science teaching

	-	**n/u**	**+**
(B13)I find it difficult to teach science	37.9	34.1	27.9
(B14)I like presenting science-related topics/themes/activities in my classroom	16.0	26.0	58.0
(B15)I am a good science teacher	20.0	50.6	29.4
(B16)I feel comfortable answering Foundation Phase learners' questions on science	8.8	12.6	78.6
(B17)I feel confident about my abilities to teach science to Foundation Phase learners	9.3	13.8	76.8
(B18)I lack the knowledge and skills to teach Natural Science effectively	46.9	24.9	28.1
(B19)I believe that science should be taught by a specialist teacher	36.5	19.3	44.1
bb2: $\bar{x}$ = 3.27 (= 0.42)			

A significant number of teachers indicated that they like presenting science, that they feel confident about their abilities to teach science, that they are satisfied with their own knowledge and skills to teach science effectively, and that they do not find it difficult to teach science. It is therefore interesting that the majority of the respondents were uncertain whether they are good science teachers (51%) and indicated that they believed that science should be taught by a specialist teacher (44%). This may signify an underlying uncertainty with regard to science teaching that teachers are not comfortable to acknowledge.

From this data, it appears as if teachers in general do not lack confidence in teaching science. The term “science” however - as stated previously - encompasses various content areas. Respondents already indicated that they preferred content from the Life sciences - the question therefore arises whether their content knowledge covers the wide spectrum of science-fields or only the topics they like and are familiar with (see 4.7.1 and results of bb1).

- **Results for specific research problem 3 (**Cluster 3: bb3)
  View and understanding of the nature of science

	-	**n/u**	**+**
(B20)I believe that science consist of facts, concepts and theories that have to be taught in the classroom	13.9	14.4	71.7
(B21)Science in the Foundation Phase equals doing experiments	16.2	20.8	62.9
(B22)I feel that Foundation Phase learners can learn many important values and attitudes through science	3.9	13.9	82.2
(B23)I believe that science is part of our everyday life	1.1	4.4	94.5

Almost 72% of the teachers indicated that science consists of facts, concepts and theories that have to be taught in the classroom (which refers to the knowledge-base of science). However, it becomes evident that the majority do have an inclusive understanding of the multi-dimensional nature of science, by also acknowledging the processes as well as the values and attitudes that are equally part of science in our everyday life. It is therefore fair to infer that the teachers from this sample seem capable of portraying the multi-dimensions of science effectively in their teaching, even though they may not be clear about other components of science.

- **Results for specific research problem 4** (Cluster 4: bb4)
  Perceptions regarding the abilities of Foundation Phase learners to learn Natural Science

	-	n/u	+
(B24)I believe that all Foundation Phase learners are natural scientists	18.8	30.9	50.3
(B25)I think that all Grade R-3 learners can learn science	4.4	11.1	84.5
(B26)I believe science is too difficult for some Foundation Phase learners	47.5	27.6	24.9
(B27)Children can lead happy, useful lives without being scientifically literate	52.1	25.4	20.4

A sizable majority of respondents view all Foundation Phase learners as capable natural scientists that need to become scientifically literate in order to lead successful lives. It is therefore fair to infer from this data that these teachers seem able to provide experiences to build a solid foundation for developing scientific literacy.

As found in literature (see 2.5.2.4 and 2.5.3), the achievement of scientific literacy depends on the acquisition of scientific knowledge, skills, values and attitudes. Scientific literacy therefore has to be a conscious goal, even at primary level. It must be noted that, although the importance of science and the need for learners to achieve scientific literacy are well acknowledged by teachers, their understanding of the meaning of scientific literacy was not tested. Their perceptions about their own level of scientific literacy raise concerns about whether teachers will be able to promote scientific literacy among learners when they do not regard themselves as scientifically literate.

- **Results for specific research problem 5** (Cluster 5: bb5)
  Perceptions regarding appropriate methods for Natural Science instruction

	-	n/u	+
(B28)I know how learners learn science best	18.2	35.4	38.1
(B29)I provide opportunities for learners to do practical work in science	17.3	19.9	61.3
(B30)I try to provide opportunities for learners to construct their own knowledge and understanding of science	12.2	23.2	62.9
(B31)I think that science knowledge is best acquired through rote-learning (memorisation)	80.1	12.2	7.7
(B32)I am aware of the teaching method most suitable for Natural Science in the Foundation Phase	23.2	34.3	37.6

(B33)I try to establish each learner's prior knowledge before I teach new science content	11.6	25.4	61.3
(B34)I mainly use worksheets to assess learner performance in science	34.4	24.4	35.6
(B35)I provide opportunities for learners to learn science by doing hands-on science	8.9	21.1	69.4
(B36)I am skilled at promoting critical thinking and problem-solving in science	12.6	37.4	49.5
(B37)I provide ample opportunities for learners to work with concrete materials in science	20.4	26.5	52.5
(B38)I provide ample opportunities for learners to share their science experiences in class	13.3	21.1	65.0
(B39)I mainly transmit science knowledge through telling the learners about science	29.4	23.7	39.5
(B40)I think group work is essential for effective science learning	10.1	24.0	65.9
(B41)My classroom is structured in such a way as to promote hands-on exploration and manipulation of concrete materials for science	36.5	29.3	20.4
(B42)I like to organise group work activities for science	25.4	29.4	42.4
(B43)It is easy to cater for different learning styles in Natural Science	22.9	36.9	36.9
(B44)I need a fully-equipped science laboratory to present science experiences for Foundation Phase learners	34.3	15.2	24.7
bb5: $\bar{x}$ = 3.17 (= 0.51)			

A third of the teachers (38%) indicated that they are familiar with the way in which Foundation Phase learners learn best, as well as with the most suitable methods for science instruction (38%). This is important knowledge for teachers since the creation of meaningful learning in science depends on effective instruction and correct understanding of how children construct knowledge. From this data, it appears that teachers may not necessarily *knowingly* follow a constructivist approach to teaching science, but that their responses can be derived from a constructivist view (see par. 3.2; 3.5). Most teachers (61%) indicated that they do establish each learner's prior knowledge before teaching new science content (see par. 3.5.2).

From this data, it would be reasonable to infer that, typically, science teaching is based around practical work (61%) with hands-on (69%), concrete experiences (53%), knowledge construction (63%), communication of scientific ideas (65%) and cooperative learning experiences (42%). It also is interesting to note that, although 65% of the teachers acknowledge the importance of group-work activities, only 42% *like* organising group-work activities for science.

In line with OBE principles, teachers predominantly pointed out that rote-learning is not the best way to learn science. Still, a significant number (40%) indicated that they do act as “tellers of science”, thus focusing on the oral transmission of science information, and portraying a behaviourist perspective (see par. 3.2). Roughly a third of the respondents indicated that assessment mainly takes place by means of worksheets, therefore betraying a focus on content knowledge. This hopefully indicates that the remaining respondents also assess the - just as important - processes and attitudes of scientific enquiry in more appropriate ways.

In recent times, it is required of teachers to try to learn as much as possible about each learner and their preferred styles of learning, and then develop a flexible, adaptable and multifaceted teaching style. In planning learning experiences for young learners, it is therefore essential that teachers consider individual and culturally determined styles of learning because learners benefit by means of their preferred style (see 3.4.2 and 3.7.10). Whether teachers are equipped to cater for different learning styles when planning for science experiences, is not perfectly clear. While 37% indicated that they do find it easy, a significant further 37% are *undecided,* while the remaining respondents are not catering for different learning styles at all.

Although the majority of teachers realise that a science laboratory is not a requirement for teaching science effectively, it is observed that the *learning environment* created in their classrooms is generally not perceived as conducive to science investigations, as they do not allow for free exploration and discovery of science. Learners are therefore dependant on the teacher for their encounters with science.

- **Results for specific research problem 6** (Cluster 6: bb6)
  Perceptions regarding the priority for Natural Science education in the Foundation Phase curriculum

	-	n/u	+
(B45)I believe that the main priorities for learning in the Foundation Phase are literacy and numeracy	13.8	6.6	72.4
(B46)To me, the teaching of science in the Foundation Phase is as important as the teaching of reading	34.4	18.7	46.7
(B47)I think that the teaching of science skills in the Foundation Phase is as important as the teaching of mathematical skills	26.4	17.6	53.3
(B48)I think that the teaching of science skills in the Foundation Phase is as important as the teaching of life skills	18.7	14.3	65.4

(B49)Science education should only have minor emphasis before Grade 4 (Intermediate Phase)	32.8	19.4	37.2
(B50)I feel satisfied that a solid foundation for Natural Science is provided during Grade R-3 phase	23.3	36.1	38.3
(B51)I believe that learners in the Foundation Phase are incapable of learning science	44.2	13.3	16.0
(B52)It is important to develop scientific knowledge and understanding in the Foundation Phase	7.7	13.2	79.1
(B53)Science must be given a higher priority in the Foundation Phase	22.7	28.7	48.6
(B54)I think that the time allocated for Natural Science in the Foundation Phase-curriculum is sufficient	25.7	22.9	51.4
bb6: $\bar{x}$ = 3.27 (= 0.42)			

In line with findings in literature (4.7.2.3), the situation in South Africa is no different to that in other countries, as a substantial majority of respondents (72%) regard *Literacy* and *Numeracy* as the main priority for the Foundation Phase, thus focusing on the traditional three R's. Arranged in sequence, 65% of respondents regard Natural Science just as important as *Life skills*, 53% as important as *Mathematics,* and 47% as important as *reading*. It is interesting to note that most respondents indicated that they regard Natural Science as of equal importance to Life Skills, which may indicate where Natural Science would most often be integrated. The result may be due to the confusion that the Natural Science Learning Area forms part of the Life Skills Learning Programme.

The issue of the priority of science is difficult to determine from the data. It emerges that teachers are divided regarding their perceptions of the priority for science in the Foundation Phase. While 51% of the respondents indicated that the time allocated to Natural Science is sufficient, 49% indicated that it should be given higher priority. Only 38% of the teachers feel satisfied that a *solid foundation* is provided during the Foundation Phase. It can therefore not be concluded with certainty that teachers from this sample view science as a main priority in the Foundation Phase.

- **Results for specific research problem 7** (Cluster 7: bb7)
  Understanding of the place (integration) of the Natural Science Learning Area in the Foundation Phase curriculum

	-	**n/u**	**+**
(B55)In the Foundation Phase, Natural Science should be integrated into the core Learning Areas (Mathematics, Languages, Life Orientation) as an **additional** Learning Outcome	16.2	17.9	60.1
(B56)I like to integrate science into the Numeracy Learning Programme	18.2	19.3	62.4
(B57)I like to integrate science into the Literacy Learning Programme	18.2	18.8	63.0
(B58)I like to integrate science into the Life Skills Learning Programme	5.6	17.8	76.7
(B59)I believe that Natural Science should **ALWAYS** be taught as part of the Life Skills Learning Programme	23.3	26.1	50.6
(B60)I believe that science is **best taught** in an **integrated** way in the Foundation Phase	7.26	23.5	69.2
(B61)It is easy to integrate Natural Science **naturally** into the Learning Programmes	10.6	17.9	71.5
(B62)It is easy to strike a balance between **integration** and **conceptual progression** in Natural Science	12.5	39.8	47.4
(B63)I think science should be taught as a separate subject	58.2	23.7	18.1
(B64)I believe that **competence** in Natural Sciences can be attained through the presentation of science in an *integrated way*	6.3	28.4	65.5
bb7: $\bar{x}$ = 3.62 (= 0.62)			

The *place* of the NSLA in the outcomes-based curriculum is fully *integrated* into *all three* the Learning Programmes for the Foundation Phase (see par. 4.6.5). It seems as if teachers have a clear understanding of what integration entails (see par. 4.2.3). A clear majority (60%) of this sample is supporting the fact that the Learning Outcome in Natural Science should be taught in an integrated way as an additional Learning Outcome. Most teachers support the idea that *competence* can be attained by the natural integration of science. Arranged in sequence, teachers' preference for a Learning Programme in which to integrate science is as follows: (1) Life Skills 76%; (2) Literacy 63% and (3) Numeracy 62%. Although a significant number of respondents indicated that they integrate science in all the Learning Programmes, 50% of the respondents believe that Natural Science is part of the Life Skills Learning Programme. This confirms the researcher's suspicion that some confusion exists in this regard.

When taught in an integrated way, it is important that gradual progression with regard to the acquisition of the content of a subject should occur. Without close coordination and careful selection, the same topic or theme may be repeated over years, resulting in learners in different grade levels dealing with the same problems (e.g. the body), and losing interest as a result (see par. 4.2.4.5 (ii) *Weaknesses of the integrated curriculum approach*). While most respondents (47%) find it easy to balance *integration* and *conceptual progression*, almost 40% indicated their uncertainty in this regard.

From the above data, specifically the fact that 50% of the respondents are under the impression that Natural Science belongs to the Life Skills Learning Programme, it is reasonable to infer that half of the respondents from this sample do not fully understand the place of Natural Science in the Foundation Phase curriculum.

- **Results for specific research problem 8** (Cluster 8: bb8)
  Awareness of the *number* and *meaning* of the Learning Outcomes for the Natural Science Learning Area in the Foundation Phase

	-	**n/u**	**+**
(B65)In the Foundation Phase, only LO1 of the Natural Science Learning Area is taught and assessed	18.9	31.6	49.2
(B66)The LO for Natural Science in the Foundation Phase focuses on ***scientific investigation***	13.6	27.1	59.3
(B67)I believe that the *weighting* of the Natural Science Learning Outcome in the Foundation Phase is sufficient to provide a solid foundation for science education	22.5	32.6	44.9
(B68)There is inadequate time for teaching LO1 of Natural Science in the Foundation Phase	35.6	26.0	38.4
(B69)I think that competence in LO1 of Natural Sciences is sufficient to promote **scientific literacy** in Foundation Phase learners	19.2	35.6	45.2
(B70)I feel that competence in the LO1 for the Natural Science Learning Area is sufficient to provide a **solid science foundation** to build on in the Intermediate Phase	23.3	30.7	46.0
(B71)I believe that the **scientific investigative process** is central to the Natural Science Learning Area for the Foundation Phase	9.1	33.1	57.7
(B72)I am aware that the scientific investigative process includes *planning, doing and reviewing*	5.1	14.1	80.4
(B73)I provide science experiences for Foundation Phase learners that cover the **complete** *scientific investigative process*	17.51	43.5	39.0
(B74)There are three or more Learning Outcomes in Natural Science that must be addressed in the Foundation Phase	12.2	38.4	49.4

(B75)*Competence* in LO1 enable learners to **solve problems**	6.8	35.0	58.1
bb8: $\bar{x}$ = 3.37 (= 0.51)			

It seems as if teachers are well aware of the *meaning* of Learning Outcome 1, as well as the Assessment Standards (planning, doing, reviewing) for this LO. Although 80% of the teachers indicated with certainty that they are aware of the Assessment Standards (planning, doing, and reviewing; see par. 4.6.2.2), the majority of the respondents (44%) were *uncertain* whether they provide science experiences to cover the complete investigative process represented by these Assessment Standards. It therefore remains unresolved whether they support learners to achieve the outcome of *scientific investigation* represented by LO1. As seen in Chapter 1 (1.2.1.1.(a)), the Grade 6 learners that took part in the *Grade 6 National Systemic Evaluation* achieved the lowest score for LO1 of the Natural Science Learning Area (with an average of 35%). It therefore seems crucial that Foundation Phase learners are provided with opportunities to achieve LO1 at this level.

Another important observation from the data is that, although the respondents seem to understand the meaning of LO1, it remains unclear whether they are sure about the *number of* Learning Outcomes to be taught and assessed in the Foundation Phase. Control items (B65, B74) were included to establish whether respondents are aware of the number of LO's for the Foundation Phase (there is only one; see par. 4.6.2.1). While 49% of the respondents indicated that there is only one LO for the Foundation Phase, another 49% indicated that there are *three or more* LO's for this phase. Approximately half of the respondents in the sample were not aware of how many LO's they are supposed to achieve in the Foundation Phase.

- **Results for specific research problem 9** (Cluster 9: bb9)
  Understand and use the process skills as set out in the Natural Science Learning Area Statement

	-	n/u	+
(B76)I am aware of the process skills as set out in the Natural Science Learning Area Statement	17.92	37.9	45.1
(B77)I believe that, for Foundation Phase learners, the **process of investigation** in science is as important as the **content** of science	8.52	16.5	75.0
(B78)I intentionally seek ways to involve the process skills during Natural Science activities	12.42	34.5	53.1
(B79)I provide opportunities for Foundation Phase learners to use the science process skills in a variety of settings	14.8	31.8	53.4
(B80)I believe that Foundation Phase learners are too young to use investigative process skills	62.5	22.7	14.8
(B81)I believe that the process of investigation in the classroom is the same as the one conducted in the science laboratory	46.3	28.8	24.9
(B82)I understand what each of the process skills involve	17.1	42.9	40.0
(B83)I often use the **process skills** *plan, do* and *review*	16.0	33.1	50.9
(B84)*Investigate, reflect,* and *analyse* are process skills listed in the Natural Science Learning Area	6.25	32.9	60.8
bb9: $\bar{x}$ = 3.32 (= 0.55)			

Learners at all grade levels should have the opportunity to use scientific enquiry, and develop the ability to think and act in ways associated with enquiry (see par. 2.5.3.2 and 4.6.3.1). Teachers unconditionally support the idea that the *process* of science is as important as the *content*. 45% know and 40% understand the process skills, and 53% that they intentionally involve the use of the process skills in a variety of situations.

Process skills are used to solve scientific problems. The *scientific investigative process* in the class could be regarded as equivalent to that conducted in the science laboratory (see par. 2.5.3.2 and 4.6.3.1). The majority of respondents does not acknowledge this. Furthermore, although most respondents indicated that they know and understand what the process skills involve, the countercheck questions (B83, B84) prove the contrary. 51% of the respondents indicated that B83 *(Plan, do, review*) are process skills, which are in fact the *Assessment Standards* for LO1. 61% chose B84 (*Investigate, reflect,* and *analyse*) which are also not process skills listed in the Natural Science Learning Area.

Respondents' uncertainty regarding the process skills also surfaces in the open questions (Section C). Teachers were required to indicate the process skills that they most frequently use during their science activities. A summary of the responses to C2 follows:

- In most cases, no responses were provided.

- A number of respondents provided answers that were clearly influenced by the countercheck items included in the questionnaire, e.g., the AS's of B83 (*plan, do* and *review*). Many respondents included the words of B84 (*investigate, reflect,* and *analyse*) which are also not process skills listed in the Natural Science Learning Area.

- An alarmingly low number of respondents included skills such as investigation, experimentation, and skills such as group discussion or completing worksheets - which could relate to process skills - in their responses.

- The majority of respondents listed the following as *process skills* they most frequently use:

• *We don't have any.*
• *All three (Referring to the 3 AS's).*
• *Recipes, baking.*
• *Balloon blow, colour mix, air movement, water boiling.*
• *Concrete activities.*
• *Do, touch, experience.*
• *The world around us.*
• *Change. Solar energy.*
• *Recycling.*
• *Research, cut and paste.*
• *Mind maps.*
• *Group work.*
• *Practical application in daily situations.*
• *Technological processes.*
• *Building structures.*
• *Model - homes.*
• *Explain, motivate.*
• *Examples and explanation of specific themes.*
• *Posters, discussions, questionnaires.*
• *Practical self-exploration.*
• *Independent participation in planned activities.*
• *Life skills.*

- *Art.*
- *Life, Earth, Space and Biological sciences.*

It is evident that a significant majority of this sample does not know what the process skills involve, and will therefore not be able to facilitate the process of investigation effectively to reach the outcome of LO1 (scientific investigation).

- **Results for specific research problem 10** (Cluster 10: bb10)
  Perceptions regarding the selection of developmentally appropriate Natural Science content

	-	n/u	+
(B85)When I plan science learning experiences, I prefer to use content and concepts from the content area *Life and Living* as described in the Natural Science Learning Area	11.9	28.4	59.7
(B86)I feel comfortable to provide learning experiences and activities from the strand *Energy and Change*	21.7	40.0	38.3
(B87)I like presenting activities from the strand *Matter and Materials*	24.3	38.7	37.0
(B88)Content from *Planet Earth and Beyond* is inappropriate for Foundation Phase learners	50	24.4	25.6
(B89)I make provision for science education in the Foundation Phase through science topics or themes	18.3	25.1	56.6
(B90)It is difficult to find resources for science	63.6	21.6	14.8
(B91)It is easy to find appropriate science content from **local contexts**	16.6	25.7	57.7
(B92)I use mainly books as resources for science	29.0	20.5	50.6
(B93)I know how to select developmentally appropriate science content for Foundation Phase learners	18.6	34.3	47.4
(B94)I find at least 30% science content from the local context	21.1	33.7	45.2
bb10: $\bar{x}$ = 3.17 (= 0.43)			

It is fair to infer from this data that developmentally appropriate content for science topics and themes is easily found (64%), mainly from books (51%) and that content is also found from local contexts (58%), thus implying that local or indigenous knowledge is included as required by Natural Science Learning Area Statement.

Respondents indicated that they like to choose content from the range of core knowledge and concepts, arranged in order of preference: (1) Life and Living (60%); (2) Planet Earth and Beyond (50%); (3) Energy and Change (38%); and (4) Matter and Materials (37%). These preferences correspond with their personal preferences (see personal experiences -bb1) where Biological sciences were preferred above Earth and Space sciences and Physical sciences.

To achieve the curriculum aim of *scientific literacy*, the foundation of understanding across a range of ideas from all the content areas have to be laid during primary science. The teacher should possess sufficient background knowledge over the whole range of content areas in order to teach science effectively. As suggested in literature (see par. 4.6.4.1; 4.7.2.2), teachers' lack of subject knowledge in science has been documented and frequently identified as a barrier to the implementation of curriculum reform and learner progress. Although teachers' content knowledge was not tested, many indicated that they least prefer science content from *Energy and Change* and *Matter and Materials*. Teachers who lack content knowledge and confidence often attempt to minimise their difficulties by avoiding particular science topics, by heavily relying on texts, and by overemphasising practical activity. These strategies may result in an impoverished science education. Research also pointed out the *misconceptions* that primary teachers themselves are likely to bring into the classroom when dealing with topics that they are not knowledgeable about, for instance topics from Earth and Space sciences (see par. 4.7.1).

Another important observation is that the majority of respondents were *undecided* with regard to choice of the content areas *Energy and Change* and *Matter and Materials*. This could be due to the fact that teachers are unaware of the prescribed knowledge strands in the Natural Science Learning Area document. The question recurs whether teachers only integrate their favourite topics in science, or whether they specifically and systematically follow the guidelines of the Natural Science Learning Area to cover the full range of science knowledge and concepts.

From the above data, it may be assumed that, while respondents seem capable of selecting developmentally appropriate science content, it cannot be concluded with certainty that the content they choose covers the broad spectrum of core knowledge and concepts. It remains inconclusive whether a solid knowledge foundation for future conceptual understanding over the full range of content knowledge is laid in the Foundation Phase.

- **Results for specific research problem 11** (Cluster 11: bb11)
  Perceptions regarding pre- and in-service training

	-	n/u	+
(B95)During pre-service (tertiary) training, Natural Science was one of my modules/subjects	50.2	11.4	38.3
(B96)In pre-service (tertiary) training, I learned the basics of science (Biological, Life, Earth and Space Science)	34.7	12.5	52.8
(B97)In pre-service (tertiary) training, we explored different methods to teaching science	44.6	16.6	38.9
(B98)I have had authentic science experiences during pre-service training	42.5	14.9	42.5
(B99)I have learnt the basics of science during my own school years	19.4	9.7	70.9
(B100)I acquire the science knowledge I need to teach science through self-study	18.6	20.5	60.8
bb11: $\bar{x}$ = 3.06 (= 0.90)			

With regard to pre-service training, a significant percentage of respondents (50%) indicated that they did not have Natural Science as a module during their initial teacher-training, and that they did not explore different science teaching methods.

A good majority of the respondents (71%) indicated that they acquired their content knowledge from their own school years. It may be inferred that teachers who had both Biology and Science as school subjects will have at least some knowledge base from which to draw in their own teaching. While 50% of the respondents indicated that they did not have Natural Science as a subject at all, 53% said that they learned the basics of science during their teacher-training course. As claimed by scholarship, courses in Natural Science presented during pre-service training are generally too short to cover the breadth of science, so that teachers are expected to draw upon and develop their own subject knowledge to a significant extent. From this sample, a large number of respondents (61%) indicated that they acquire their content knowledge through self-study. This corresponds with research on the topic. The problem, however, is that teachers' own prior knowledge of science often lack breadth as well as depth.

Regarding in-service training, the results are as follows:

	-	n/u	+
(B101)I received training on how to implement the Revised National Curriculum Statement (RNCS)	9.0	11.3	79.7
(B102)I feel satisfied about the training I received on how to implement the RNCS	23.7	17.5	58.8
(B103)I feel that the training I received equipped me adequately to integrate the Natural Science Learning Area specifically	30.3	27.0	42.7
(B104)In the RNCS training, I learned about the process skills	26.0	24.9	49.2
(B105)In the RNCS training, I learned how to use the process skills	27.4	28.0	43.6
(B106)I received in-service training on how to interpret the Natural Science Learning Area for the Foundation Phase	33.5	29.0	37.5
(B107)I understand what the Natural Science Learning Area for the Foundation Phase entails	13.0	28.3	58.8
(B108)I am familiar with the content of the Natural Science Learning Area that applies to the Foundation Phase	14.1	28.3	57.6
(B109)In my school, we receive sufficient guidelines on how to integrate Natural Science effectively	23.7	36.7	39.5
(B110)I feel that I receive sufficient support from the provincial department on the implementation of the Natural Science Learning Area	47.1	32.6	20.2
(B111)I feel that I need more training on the Natural Science Learning Area	23.0	19.7	57.3
(B112)I would like to have more science curriculum resources	4.0	15.3	80.8
(B113)I received sufficient training to design learning programmes, work schedules and learning units	23.7	28.8	47.5
(B114)When I design learning programmes, work schedules and learning units, I intentionally seek opportunities to integrate Natural Science	16.4	29.9	53.7
bb12: $\bar{x}$ = 3.33 (= 0.58)			

Most of the respondents received RNCS-training (80%). They feel satisfied about the training that they received (59%); they claim to know and understand the Natural Science Learning Area document, and say that they are able to implement it in the Foundation Phase (58%). Teachers also claimed to be properly skilled in developing learning programmes, work schedules and learning units, and said that they intentionally integrate Natural Science in the aforementioned.

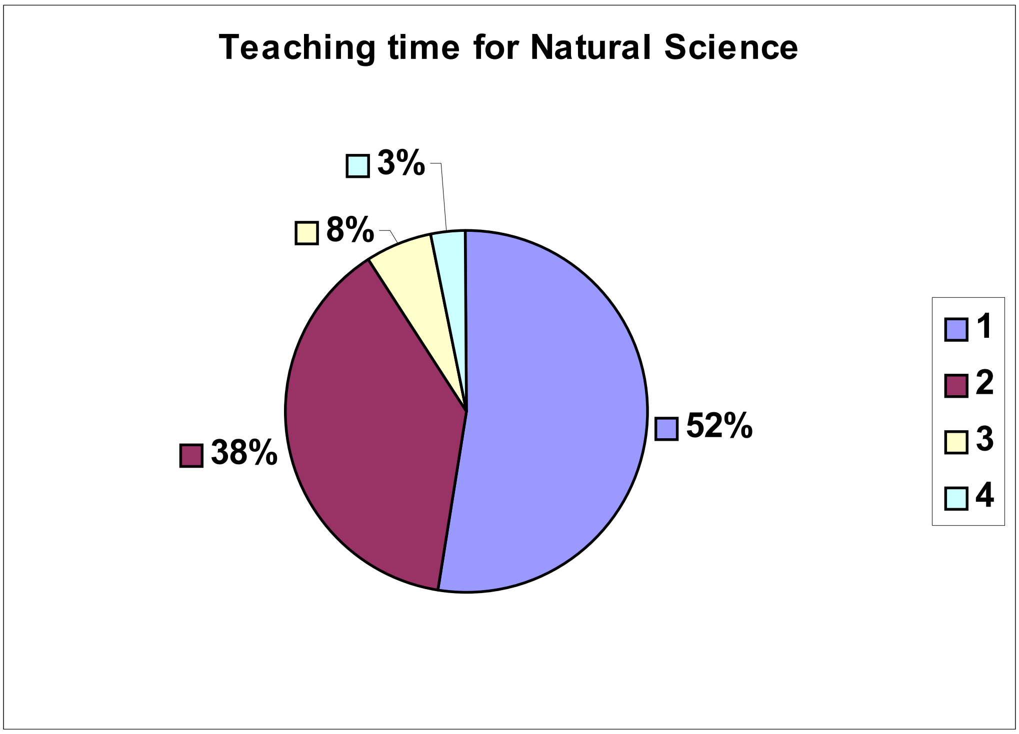
With regard to training in the process skills, 49% of the respondents indicated that they learned about these during their training, and 43% said that they learned how to use them. This leaves an alarmingly large number of respondents without sufficient training in this regard. As previously found, teachers do not necessarily know what the process skills are and are consequently not necessarily familiar with the process skills approach towards teaching science.

A majority of respondents (57%) indicated that they would like to have more training on the Natural Science Learning Area, and 47% wished they received more support from the provincial government. A significant number (81%) of respondents also indicated that they would like to have more curriculum resources.

From the data pertaining to both pre-service and in-service training, it appears that teachers feel inappropriately trained to implement the Natural Science Learning Area. Whether they are properly trained to reach the aim of the Natural Science Learning Area through their teaching - that is, to promote scientific literacy - is difficult to assess, but all indications suggest that they are not.

- **Results for specific research problem 12** (Cluster 12: bb12)
  Actual time spent on Natural Science teaching in the Foundation Phase

DIAGRAM 4



(Question B115)

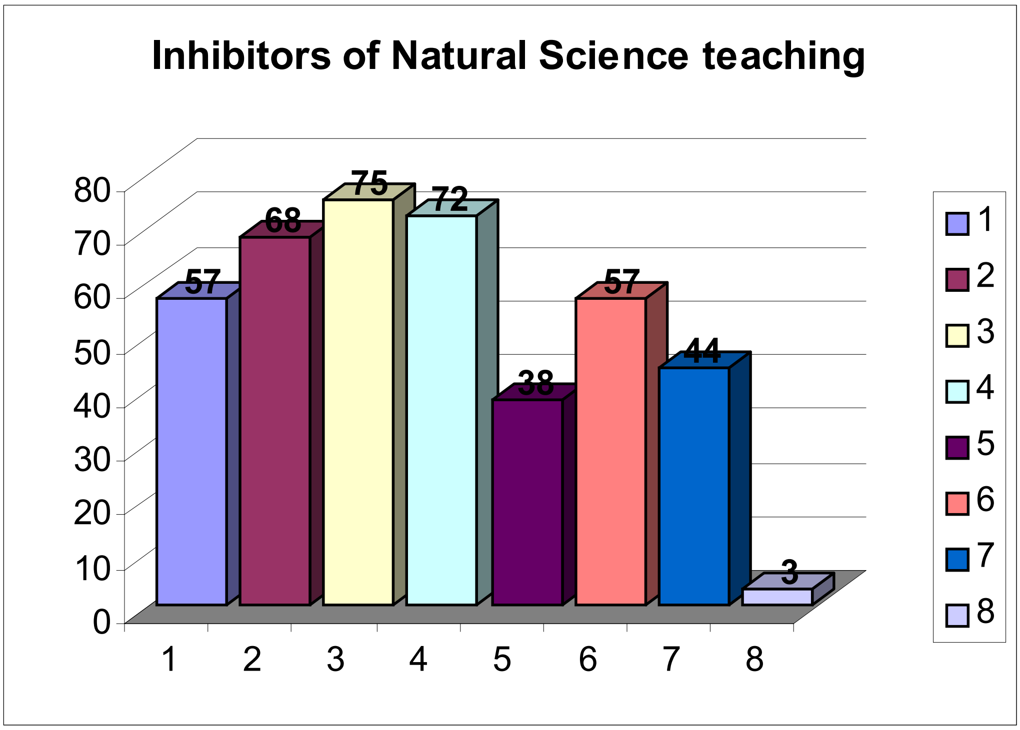
1 = I integrate LO1 of Natural Science at least **once a week** in one of the Learning Programmes
2 = I integrate LO1 of Natural Science at least **once a month** in one of the Learning Programmes
3 = I integrate LO1 of Natural Science at least **once a term** in one of the Learning Programmes
4 = I **rarely** integrate the Learning Outcome/s for Natural Science

Attempting to determine exactly how much science is taught in the primary schools, appears to be problematic. Great variety exists between teachers and between schools, but on average, 52% teachers indicated that science was taught at least once a week, leaving at least 48% of teachers not teaching enough science. Opportunity was provided for teachers to indicate the *actual time* that they spend on teaching Natural Science in each of the Learning Programmes *per week* in the open questions (Section C). It seems as if teachers' responses could be influenced by expectations of how much science should be taught. Where science is integrated in other Learning Areas, separating the science component is very difficult. The times ranged from *0 minutes* to 9 hours 10 minutes in a Learning Programme. In some instances, the actual times filled in for *science teaching* in each Learning Programme added up to a total of *22 hours, 30 minutes*, leaving no time for anything else. The times indicated are therefore often unrealistic and incoherent, providing an unreliable picture of what actually happens in class. The findings should be considered unreliable and consequently unusable.

- **Results for specific research problem 13** (Cluster 13: bb13)
  Factors inhibiting the teaching of Natural Science in the Foundation Phase

The factors indicated by teachers as the most important inhibitors, are provided in DIAGRAM 5.

DIAGRAM 5



1 = Large classes (B116)
2 = Poor resourcing (B117)
3 = Overcrowded curricula (B118)
4 = Inadequate teaching time for Natural Science (B119)
5 = Lack of knowledge and skills to teach science (B120)
6 = Inadequate curriculum resources (B121)
7 = Inadequate **Learning Outcomes** for Natural Science in the Foundation Phase (B122)
8 = Other (B123)

This data indicate that the most significant factors limiting the quality of primary science are *overcrowded curricula*, *inadequate teaching time* and *poor resourcing*. The 3% *other* inhibitors were all related to *disruptive behaviour* and *discipline problems* in classes, but also to the *demands of the curriculum* regarding literacy, numeracy and perceptual development.

A relatively low number of respondents (44%) indicated *inadequate Learning Outcomes* for Natural Science in the Foundation Phase as inhibitor. This relatively low score may be due to the fact that teachers are not fully aware that only one Learning Outcome is taught and assessed in the Foundation Phase (see results for specific research problem 8).

The open questions in Section C were included to shed more light on specific aspects. While items B116-123 (Specific research problem 13) explored factors that *inhibit* the teaching of science, item C3 requested teachers to suggest ways in which science education can be *improved*.

Teachers' suggestions to improve Natural Science education are grouped under the following headings:

- *Learning support materials / resources / equipment*.

Suggestions included ideas for elementary experiments; pre-planned lesson that can be readily presented; and guidelines in terms of appropriate themes and activities for the Natural Sciences.

- *Curriculum adaptations*

Increased teaching time for Natural Science; an increased number of LO's for the Natural Science Learning Area; Natural Science as compulsory subject.

- *Training and support*

Increased support by means of adequate training material for teachers who lack a science education background; workshops; networking and sharing of ideas; visits from experts; mentoring; support from the government; guidelines on each Learning Area specifically; fully skilled teachers or experts in a school that can help with Natural Science education.

- *Facilities*

Some teachers indicated that a fully equipped science laboratory is needed for Natural Science education in the Foundation Phase, but more appropriate suggestions included aspects such as adequate facilities (e.g. the availability of electricity in each classroom) and adequate class conditions (e.g. the number of learners in a class). In many cases classes are too large to facilitate Natural Science effectively.

- *Motivators for learners*

Science exhibitions (Expo's) or competitions to motivate learner participation in Natural Science activities.

5.10. 3 Item analysis and Cronbach alpha coefficient to establish item reliability

In the previous section (5.10.2), the responses on specific aspects regarding Natural Science education in the Foundation Phase were examined. The tables of percentages gave a general view of respondents' perspectives on *each item* in the questionnaire. In order to obtain a summative impression of respondents' perceptions of the main aspects addressed in the questionnaire, a measure of central tendency, or in other words, a mean value/score for each of the twelve clusters (Specific research problems 1-12), was calculated

Please note: Tables 1, 1A, 2 and 3 were provided by the *Research Support Unit* of the *UNISA Computer Services*.

5.10.3.1 Item analysis and Cronbach alpha coefficient

On calculating of a measure of central tendency, the question arises as to whether the measurement calculated truly represents the aspect addressed in the specific cluster. In other words, do all items included in the specific cluster contribute towards explaining the aspect? This has to be established prior to using the measure of central tendency or mean score in further analysis, or to make any deductions regarding the implications of such measure of central tendency. Item analysis is a statistical technique used to evaluate item reliability. Separate analyses were conducted on each cluster (establishing perceptions regarding different aspects of Natural Science education). Item reliability can be established by examining the Cronbach alpha coefficient for each aspect. As a rule of thumb, values approximately greater than 0.7 indicate reliability. Item analysis results also identify items that do not contribute towards explaining the aspect under investigation, or items that were stated in the negative. By removing or inverting items, Cronbach alpha coefficient can be improved; thus improving reliability. The results are presented in TABLE 16 below (each row in the table represents a separate analysis).

TABLE 16: SUMMARY OF ITEM ANALYSES

Summary of item analyses results performed on aspects relating to Natural Science education in the Foundation Phase.				
Aspect (cluster)	**Cronbach alpha coefficient**	**Items included**	**Items reversed and included**	**Items excluded**
bb1. Personal experience	0.81	B1-B11	B6	B12
bb2. Confidence	0.75	B14-B17	B13 B18	B19
bb3. Nature of science	0.53	Not suitable		B20-B23
bb4. Learners' ability	-0.11	Not suitable		B24-B27
bb5. Method	0.84	B28-B44		
bb6. Priority for science	0.79	B45-B48 B50 B52-B53	B45 B49 B51 B54	
bb7. Place/integration	0.84	B55-B62 B64		B63
bb8. Learning outcome	0.80 $ (0.80)	B65-B75 (B65 B76-B73 B75)		B65 B74 (control)
bb9. Process skills	0.80 $ (0.74)	B76-B79 B81-B84 (B76.B79 B81-B82)	B80	B83-B84 (control)
bb10. Suitable content	0.73	B85-B89 B91 B93-B94	B90 B92	
bb11. Pre-service training	0.81	B95-b99		B100
bb12. In-service training	0.85	B101-b114		
Note: $ - the results reported in brackets are item-analyses with control questions removed.				

Results on TABLE 16 indicate that item reliability could be established for 10 of the 12 clusters. This implies that a mean score could be calculated for the indicated aspects. The general perceptions of the respondents on the 10 indicated aspects are thus reflected in the mean score values.

The mean score values for the various aspects are indicated in TABLE 17, displayed below.

TABLE 17: MEAN SCORE VALUES

Variable	Label	N	Mean	Std Dev
bb1	personal experience	182	3.23	0.55
bb2	confidence	182	3.27	0.42
bb5	method	182	3.17	0.51
bb6	priority	182	3.27	0.42
bb7	place/integration	182	3.62	0.62
bb8	Learning Outcome	178	3.39	0.48
bb9	process skills	177	3.37	0.52
bb10	content	177	3.17	0.43
bb11	pre-service training	176	3.06	0.90
bb12	in-service training	179	3.33	0.58

A summary interpretation of respondents' perceptions on each of the ten reliable aspects can be gleaned from the table: since all the aspects have a main value greater than three, it can be deduced that overall, the respondents' perceptions were more to the positive side than the negative side. With a mean value of 3.62, the aspect of the place/integration was regarded the most positive. The respondents' perception of pre-service training was regarded as least favourable with a mean value of 3.06, thus rather undecided.

TABLE 17 summarises the respondents' general views of each of the ten indicated aspects in a single score for each aspect - which is more easily interpreted than the results of each individual item. However, the information on each individual item still remains informative.

5.10.3.2 Analysis of variance and Bronferroni multiple comparison of means test

To investigate the probable effect of the biographical information on the perceptions of the respondents regarding the different aspects of Natural Science education in the Foundation Phase, analyses of variance were performed on the different aspects' mean score values. The results are presented in TABLE 18.

TABLE 18

Summary analysis of variance results on the scores of the various construct variables addressing teachers' perceptions regarding Natural Science education at Foundation Phase level. The probable effect of biographical variables on the construct scores is investigated.
Each row represents a separate analysis. The table presents: the construct analysed, error degrees of freedom and general F-probability associated with the analysis, as well as the F-probabilities associated with each biographical variable.

Construct variable	df (error)	General F-prob.	Sources of variation and associated F-probabilities.					
			age	qual	experience	grade	type	medium
bb1. Personal experience	159	0.0004 ***	0.48	0.93	0.21	0.001 ***	0.07	0.016*
bb2. Confidence	159	0.17	-	-	-	-	-	-
bb5. Method	159	0.0005 ***	0.15	0.390	0.05*	0.22	0.002 **	0.03*
bb6. Priority for science	159	<0.0001 ***	0.14	0.90	0.26	0.96	0.16	*** <0.0001
bb7. Place/ integration	159	0.0004 ***	0.04*	0.28	0.32	0.60	0.005 **	0.16
bb8. Learning outcome	156	0.01** (0.02**)	0.88 (0.74)	0.04* (0.06)	0.39 (0.38)	0.10 (0.16)	0.40 (0.19)	0.52 (0.48)
bb9. Process skills	155	0.47 (0.59)	- -	- -	- -	- -	- -	- -
bb10. Suitable content	156	0.0105 **	0.21	0.35	0.91	0.86	0.01**	0.92
bb11. Pre-service training	154	<0.0001 ***	*** 0.0002	0.005 **	0.83	0.11	0.20	0.11
bb12. In-service training	157	0.88	0.72	0.60	0.97	0.86	0.39	0.73

Indicator of significance:
***Prob(F)< 0.001(at the 0.1% level of significance)
** Prob(F)< 0.01 (at the 1% level of significance)
* Prob(F)< 0.05 (at the 5% level of significance)

Once the biographical variables that significantly influenced respondents' perceptions have been identified, the next step is to determine in which way the identified biographical variable influenced their perceptions on that specific aspect. Bronferroni multiple comparison of means test compares the mean scores for the relevant aspects over the levels of the significant biographical variable. The levels that differ significantly from one another are then indicated. The mean scores for the variance levels of the biographical variables are presented in TABLE 19. Within the levels of a biographical variable, means that differ significantly are indicated by different lower case letters next to them (Please note that only aspects with means that differ significantly are included in TABLE 19).

TABLE 19

Table of construct means for significant biographical variables as established in analysis of variance.						
Construct variable	age	qualification	experience	grade	type of school	medium
bb1. Personal experience				Gr3: 3.44a GrR:3.26ab Gr2:3.17bc Gr1: 3.01c		Othr: 3.59a Eng: 3.28b Afr: 3.13b
bb5. Method			<8: 3.20a >8: 3.15a		Other 4.07a Priv: 3.39b Gov: 3.11b	Other: 3.53a Eng: 3.22b Afr: 3.08b
bb6. Priority for science						Other: 3.79a Eng: 3.28b Afr: 3.17b
bb7. Place/ integration	30+: 3.67a <30: 3.36b				Other 4.66a Priv: 3.90b Gov: 3.55b	
bb10. Suitable content					Other 3.70a Priv: 3.49a Gov: 3.55b	
bb11. Pre-service training	<30:3.69a 30+:2.91b	Hons: 3.65a Dip: 3.36a BDegr: 3.29ab Dip+: 2.83bc Other: 2.54c				
Bonferroni multiple comparison of means: Means in the same cell with different letters next to them differ significantly from one another.						

The following keys are used in the results:

(*): The biographical variables that significantly influenced respondents' perceptions (taken from TABLE 18).The level of significance is indicated with a * (see TABLE 18).

(→): The biographical variable arranged in sequence from the most positive to the least positive score (taken from TABLE 19).

The results for TABLES 18 and 19 are as follows:

Results for cluster 1: Past personal experience

Grade (***): Grade 3 → Grade R → Grade 2 → Grade 1

Medium of instruction (*): N-/S-Sotho, Tswana → English → Afrikaans

Results for cluster 5: Perceptions regarding suitable methods of teaching Natural Science

Experience (*): <8 years experience → >8 years experience

Type of school (**): Other → Private → State schools

Medium of instruction (*): N-/S-Sotho, Tswana → English/Afrikaans

Results for cluster 6: Priority for Natural Science

Medium of instruction (***): N-/S-Sotho and Tswana → English/Afrikaans

Results for cluster 7: The place of Natural Science (integration)

Age (*): 30+ → <30

Type of school (**): Other schools → Private/State schools.

Results for cluster 10: Selection of suitable content

The type of school (**): Other schools/Private school → State schools

Results for cluster 11: Perceptions regarding suitable training to implement the Natural Science Learning Area

Age (***): <30 → 30+

Qualifications (**): Honours degree/ Teaching Diploma → B degree → Higher/Further Diploma in Education → Other qualifications (Masters degree, teaching certificate, matric)

5.10.4 A summary of important results

In section 5.10 the results of the empirical investigation were provided, analysed and discussed. The purpose of this empirical survey was to explore the current situation regarding Natural Science education in the Foundation Phase from a selected population. A research hypothesis was used to assist the researcher in guiding the investigation of the problem. The hypothesis is posited as follows:

> The current situation regarding science education in the Foundation Phase does not establish a solid basis on which learners can build.

The hypothesis was tested against the results of the empirical survey, to establish whether it is supported by the evidence or not. The questionnaire was designed in such a way as to observe important aspects regarding Natural Science education. For all the aspects (Specific research problems 1 -12), the average scores of teachers' responses regarding Natural Science learning and teaching were predominantly positive. It implies therefore that a solid basis for the Natural Sciences may be provided during the Foundation Phase.

However, despite this favourable picture, a few pointers contradict this predominantly positive outcome. First, the results of international comparative studies as well as studies recently conducted within South Africa, indicate a much more negative picture with regard to Natural Science education as well as the level of scientific literacy of South African learners (see par.1.2.1.1). This reality cannot be ignored.

Secondly, countercheck and open questions also contradicted many of the positive scores, which create the impression that teachers' responses may not be a true reflection of the current state. Teachers' responses could have been influenced by their expectations of what the best response at each item should be, or from a position of ignorance.

Furthermore, the individual analyses of the items revealed many areas of concern. The *neutral/undecided* and *negative* scores added together, were in many cases greater than the positive scores. This may indicate that teachers are not too sure about many of the important aspects covered in the questionnaire.

The main areas of concern are highlighted below:

- Teachers' clear preference for the Life sciences (compare specific research problem 1 and 10).

- The low number (38%) of teachers knowledgeable about appropriate methods for Natural Science instruction (compare specific research problem 5).

- Low perceived priority for Natural Science in the Foundation Phase (compare specific research problem 6 and 12)

- Confusion regarding the place of the Natural Science Learning Area in the RNCS (compare specific research problem 7)(e.g. the misconception of 50% of teachers that Natural Science is part of the Life Skills Learning Programme).

- Confusion regarding the number of LO's for the NSLA (compare specific research problem 8; question B74).

- Lack of knowledge, understanding and use of the process skills (compare specific research problem 9 and open question C2).

- Lack of appropriate teacher training modules in Natural Science (compare specific research problem 11: Pre-service training) (50% did not take modules in Natural Science).

- Gaps in in-service training regarding the Natural Science Learning Area (compare specific research problem 11: In-service training).

The current picture of Natural Science learning and teaching in the Foundation Phase seems to be one of great disparity. Despite the positive outcome of this empirical survey, certain important aspects need to be addressed before one can conclude with certainty that a solid foundation for Natural Science education is established during the Foundation Phase. Recommendations to improve the current situation will be suggested in the final chapter.

5.11 CONCLUSION

This chapter presented the design and findings of an empirical survey of the current situation regarding science teaching in the Foundation Phase. The steps involved to address the research questions were described, and the specific research problems were stated. To test the hypothesis, a quantitative empirical research design was used. The various statistical techniques used in testing the hypothesis were also identified. Thereafter, the results of this empirical survey were given, analysed and discussed. These indicated the views and understandings of the Foundation Phase teachers from the selected sample regarding the teaching of the Natural Science Learning Area in Foundation Phase context. Comparisons of the findings were made with the general consensus in scholarship on the topic. Item analysis and Cronbach alpha coefficient to establish item reliability, as well as an analysis of variance and Bronferroni multiple comparison of means test, were presented and discussed.

At face value, the results of the survey paint a generally positive picture of the perceptions of Foundation Phase teachers with regard to science education. One may accept that this picture indicate positive aspects of the currently implemented policies of the Department of Education (RNCS). However, various warning signs suggest that the current situation in practice is not all well. Teachers from advantaged schools (see 5.10.3.2, TABLE 19) are in general less positive about the situation than teachers from historically disadvantaged areas. The situation is ambiguous. There are indicators suggesting that the latter group is better trained in current policy and curriculum requirements. On the other hand, counterchecks indicate widespread ignorance about basic concepts and aspects of policy, suggesting positive responses to be resulting from ignorance about standards and the ideal to be striven for.

In Chapter 6, the final chapter, conclusions as well as recommendations are made for the improvement of Natural Science education in the Foundation Phase.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The study investigated Natural Science education in the Foundation Phase. More specifically, it attempted to determine whether a solid foundation for Natural Science is provided at this level, which would result in the promotion of scientific literacy.

6.1.1 An outline of the research

Chapter 1 presented the rationale for the study, while Chapters 2-4 surveyed the literature on the demarcated field.

Chapter 2 offered an inclusive view of the scope of science in general, and of Natural Science education in the Foundation Phase in particular. Natural Science in the Foundation Phase comprises three interrelated components: science knowledge, science process skills, and scientific values and attitudes. Together, they promote scientific literacy at this level. Chapter 3 dealt with learning and teaching issues. Learning theories and their impact on classroom practice were reviewed, and methods of teaching Natural Science in the Foundation Phase were presented. Chapter 4 focused extensively on the Natural Science Learning Area in the Revised National Curriculum Statement. The concepts curriculum and integrated curriculum were clarified, and curriculum developments internationally and in Africa were explored.

Chapter 5 reported on a quantitative survey on perceptions and understandings of a group of South African Foundation Phase teachers towards Natural Science education. First, the research design and the research questions were outlined. Some specific research problems served as guiding and structuring principles for the survey. In the second section of the chapter, the results of the survey were presented, analysed and discussed.

While similar studies have been conducted in developed countries (as indicated in Chapter 4), no previous South African study probed the state of Natural Science education at the Foundation Phase level by means of empirical investigation. It is hoped that the findings presented in Chapter 5 will contribute to the existing body of knowledge in the field.

The present chapter presents a summary of the conclusions reached in the course of the investigation, as well as some recommendations.

6.1.2 The aims and objectives of this study

The study aimed at establishing whether the foundation for Natural Science education currently being laid at the Foundation Phase level is conducive to the promotion of *scientific literacy*. Some recommendations to relevant authorities and role players, based on the major findings were also envisaged.

The main aim found expression in terms of a general problem statement, which in turn was broken down into four research objectives. The general research problem, put as a question, is as follows:

> Does the current situation in South African schools provide a solid basis for Natural Science in the Foundation Phase on which learners can build throughout life?

Four objectives were formulated to address the general research problem. These are as follows:

(1) to offer an inclusive view of Natural Science at the Foundation Phase level;
(2) to present the views of influential learning theorists and their impact on classroom practice;
(3) to explore the Natural Science Learning Area in the Foundation Phase in current policy documents; and
(4) to explore the perceptions and understandings of teachers in the Foundation Phase with regard to Natural Science learning and teaching.

Thirteen specific research problems correspond to the various item clusters in the questionnaire. While these pertain most directly to Objective 4, they have bearing on the other three objectives as well. The specific research problems are as follows:

Specific research problem 1
Are past personal experiences of teachers with science predominantly positive or negative?

Specific research problem 2
Do teachers feel confident about their abilities to teach Natural Science?

Specific research problem 3
Do teachers understand the nature of science?

Specific research problem 4
What are teachers' perceptions of the abilities of Foundation Phase learners to learn Natural Science?

Specific research problem 5
What are teachers' perceptions regarding appropriate methods for Natural Science instruction?

Specific research problem 6
Do teachers view Natural Science as a priority in the Foundation Phase curriculum?

Specific research problem 7
Do teachers understand the place (integration) of the Natural Science Learning Area in the Foundation Phase curriculum?

Specific research problem 8
Are teachers aware of the *number* and *meaning* of the Natural Science Learning Outcomes for the Foundation Phase?

Specific research problem 9
Do teachers understand and use the process skills in their science teaching as set out in the Natural Science Learning Area Statement?

Specific research problem 10
Do teachers feel competent to select developmentally appropriate science content?

Specific research problem 11
Are teachers appropriately trained to implement the Natural Science Learning Area in practice?

Specific research problem 12
What actual time is spent on Natural Science teaching in the Foundation Phase?

Specific research problem 13
Which factors inhibit the teaching of science in the Foundation Phase?

In this chapter, conclusions to the specific research problems are discussed in terms of the stated objectives.

6.2 CONCLUSIONS

The study's aims and objectives were reached by way of a literature study (Chapters 2-4) and an empirical survey (Chapter 5). On the basis of both of these (bearing in mind the limitations of the particular survey sample), the following represent the main conclusions of the investigation.

6.2.1 Conclusions relating to research objective 1: The meaning and purpose of Natural Science education in the Foundation Phase

- **The meaning of science**
  (See results for specific research problem 3, Chapter 5)

Science is a dynamic field with many dimensions, and with complex interrelationships with society. Scholarship stresses the fact that science amounts to more than mere facts, theories, content or knowledge about nature. In order to effectively teach young learners, teachers should be equipped to convey this broad perspective on the nature of science, its underlying philosophies, and its relation to society and culture (compare par. 2.2 and 2.4). The empirical survey suggests that teachers do have an inclusive understanding of what science entails, and that they are likely to portray the multi-dimensional nature of science in their science teaching.

- **The components of science education in the Foundation Phase**

Science education in the Foundation Phase has three basic, interrelated components: (1) science knowledge or content, (2) scientific process skills, and (3) scientific values and attitudes (see par. 2.5.2 and 2.5.3). The NSLA prescribes both core knowledge / concepts and a set of process skills, but does not mention scientific values and attitudes, even though this component is generally considered an important outcome (par. 2.5.3.3). Quality science teaching cannot afford to neglect any of the three components, since each plays an essential part in the promotion of scientific literacy.

- **The promotion of scientific literacy as purpose of science education**

The importance of scientifically literate citizens is widely acknowledged, both for ordinary people to cope in a scientifically and technologically driven world, and for fostering future scientists (see par. 2.5.2.1, 2.5.2.3 and 4.5.2.(4)). The promotion of scientific literacy is explicitly stated as the aim of the Natural Science Learning Area for Foundation Phase learners (see par. 4.5.2:2).

The empirical study had only 25% of the teachers in the sample viewing themselves as scientifically literate (see question B7, Chapter 5). This should be regarded as worrying: when teachers are not scientifically literate themselves, or do not know what the notion entails, they are unlikely to be able to promote scientific literacy in learners.

6.2.2 Conclusions relating to research objective 2: The impact of influential learning theories on classroom practice

- **Constructivist learning and teaching** (see results for specific research problem 6, Chapter 5)

Current educational thinking favours Natural Science teaching in the cognitive and social-constructivist mode (see par. 3.3). Learners should build on prior knowledge when processing new information and understanding, and they should take active part in the construction of meaning within their own social-cultural contexts. The approach contrasts with behaviouristic knowledge acquisition through transmission, rote-learning and memorisation. But it also places tremendous responsibility on the teacher for correct instruction and for establishing an environment conducive to science learning. Data from the survey suggest that, while teachers are aware of the constructivist approach, their teaching remains predominantly behaviouristic (compare B39 and par. 3.2).

- **"Children's science" and non-scientific ideas**

Teachers need to be aware of *children's science*, and give it serious consideration (see par.3.5.2 and 3.5.2.1). For meaningful learning to occur, the actual cognitive level of learners, their experiences, prior knowledge, and misconceptions should be taken into account. Understanding the learning characteristics of children is crucial, as these guide the teacher in having appropriate expectations and goals at each level, and in creating favourable learning conditions and environments. Altering or replacing non-scientific ideas (misconceptions) is not an easy task. It requires understanding, patience, creativity and appropriate methods (e.g. the conceptual change teaching method, see par. 3.7.9; 2.5.2.3). According to the survey, most teachers (61%) would attempt to establish each learner's prior knowledge before teaching new science content. Unfortunately, only 38% were aware of appropriate methods for science instruction. It is therefore imperative that teachers get proper training and guidance in methods of instruction, especially with regard to altering learners' non-scientific explanations.

- **Progression in all three science components**

There should be advancing levels of progress in all three components of science. The NSLA in fact provides guidelines for progression in the Assessment Standards (see 4.6.2.2), but not in conceptual development over the four years of the Foundation Phase. Presently, the onus lies on teachers to ensure gradual progression in conceptual understanding. Only 47% of the teachers in the survey (see question B62) indicated that they cater for conceptual progress. Educational authorities should be urged to provide teachers with clear guidelines for progress in each of the components.

- **Suitable methods for Natural Science teaching**

Science instruction should incorporate current research on how learners construct meaningful understanding (see par 3.6). Only 38% of the Foundation Phase teachers in the survey were familiar with suitable methods for science instruction (see questions B28 and B32 at specific research problem 5).

Current thinking emphasises conceptual learning through a variety of learning processes. The constructivist paradigm prescribes hands-on investigation and cooperative learning experiences (compare par. 3.7). It implies that both teacher and learners are actively involved in the learning process: the teacher as facilitator and mentor (rather than purveyor of knowledge) and the learners as active inquisitors (rather than passive recipients of information; see par. 3.6). In this way, learners can learn through authentic experience rather than through lessons pre-planned by the teacher and divorced from context. Many teachers appear to follow appropriate methods for science education (see results for specific research problem 5, Chapter 5). On the other hand, Foundation Phase classrooms are typically not conducive to science investigations, as they do not allow for free exploration and discovery of science (see question B41, specific research problem 5). Learners consequently remain dependant on the teacher to an unacceptable degree.

Current understanding of different styles of learning and thinking should be employed to create favourable conditions for learning (see par 3.4.2). The NSLA envisages a teaching and learning milieu which recognises diverse learning styles and culturally influenced perspectives (see par. 4.5.2:6). The life experiences, capabilities, interests and learning styles of learners vary significantly, so that flexibility and ingenuity in the selection of instructional strategies for science are crucial. Only 26% of the Foundation Phase teachers in the survey indicated that they cater for different learning styles when planning for science experiences (question B43, specific research problem 5). Teachers should be urged to keep up with new developments on how children learn, how to teach science effectively, and how to accommodate diverging social-cultural contexts.

6.2.3 Conclusions with regard to research objective 3: The Natural Science Learning Area in the South African context

- **Priority for Natural Science in the Foundation Phase** (see results for specific research problems 6 and 12, Chapter 5)

Natural Science education is often neglected in the Foundation Phase because of the strong emphasis on Literacy and Numeracy (see par. 4.7.2.3). The perceived low priority for science is not only a personal view expressed by teachers, but implicitly conveyed by policy documents through time-allocation, the number of LO's and the place of the Natural Science Learning Area in the Foundation Phase curriculum (compare par. 4.6.2.1). The empirical survey among local teachers supports findings in literature (4.7.2.3), namely that Foundation Phase teachers regard Literacy and Numeracy (the traditional three R's) as main priorities for the Foundation Phase,.

Scientific literacy depends on a quality science programme. Science education can only improve if it is given a high priority and better time allocation. It is safe to assume that learning achievement in a subject area is dependent on the amount of time and the quality of learning experience learners get in that subject. Foundation Phase teachers need to recognise the importance of regular Natural Science education in achieving the goal of scientific literacy.

- **The actual time spent on Natural Science in the Foundation Phase** (see results for specific research problem 13, Chapter 5)

From the conducted survey, Natural Science appears to be taught on a regular basis in many Foundation Phase classrooms. However, in many instances it remains a neglected area: 52% of the teachers participating in the survey teach science at least once a week, leaving 48% that do not teach enough science.

It is difficult to determine the actual time (in hours and minutes) teachers spend on Natural Science education in the Foundation Phase. Respondents in the survey (open section) provided unrealistic and incoherent information, giving an unreliable picture of what actually happens in class. The data probably reflect overestimations, and should be considered unreliable. However, it may be assumed that the actual time spent on teaching Natural Science has bearing on the teacher's attitude towards to Natural Science education. Foundation Phase teachers should ensure that sufficient time is allocated to the teaching and learning of all three science components (knowledge, process skills, values and attitudes) in their classrooms.

- **The place of the Natural Science Learning Area in the Foundation Phase** (see results for specific research problem 7, Chapter 5)

In the outcomes-based curriculum (RNCS), Natural Science is fully integrated in all three Learning Programmes for the Foundation Phase (Numeracy, Literacy, and Life Skills; compare par. 4.6.5). The survey reveals a significant level of uncertainty among teachers with regard to the place of the Natural Science Learning Area in the Foundation Phase, with 50% of the respondents indicating that this Learning Area is part of the Life Skills Learning Programme. The uncertainty in this regard needs to be addressed promptly. Science should be taught on a regular basis, and should by no means remain restricted to one Learning Programme only.

The high regard for science and scientific literacy in scholarly literature (par. 2.5.2.1), needs to be reflected by the place of science in the Foundation Phase curriculum. Currently, this is not the case in South African policy documents. In the RNCS, only LO1 is set aside for the Foundation Phase. The fact that this Learning Outcome is spread across all three Learning Programmes for the Foundation Phase, appears to exacerbate the problem, as that renders it even less prominent.

- **Integration and the Natural Science Learning Area**

Integration is central to outcomes-based education (see Chapter 4, par. 4.2.3.6 *Integration and C2005/RNCS*). Scholarly literature stresses the importance of knowledge integration for effective learning, especially in the Foundation Phase (see par. 4.2.3), replacing the traditional approach of teaching subjects in isolation. Teachers therefore need to have a clear understanding of what integration entails and how to teach science in an outcomes-based paradigm. Literature furthermore highlights the sophisticated skills required for the teaching of science in an outcomes-based approach.

Such skills include:
- seeking integration possibilities within and across Learning Areas;
- careful planning of the science curriculum to ensure gradual conceptual progression;
- creating meaningful learning experiences related to solving problems in their everyday lives; and
- selecting teaching methods suitable to this approach.

Teachers appear to be mostly uncertain about their ability to balance integration and conceptual progression in science (see question B62). Furthermore, traditional passive-learner instructional methods (e.g. telling about science, see B39) are still prevalent in many Foundation Phase classrooms. The result calls for ongoing support for teachers in the implementation of integrated and outcomes-based curricula, specifically to attain the single Learning Outcome for the Natural Science Learning Area.

- **The meaning of Learning Outcome 1** (see results for specific research problem 8, Chapter 5)

Only LO1 of the Natural Science Learning Area pertains to the Foundation Phase. It should be cause for concern that half of the teachers participating in the survey were not aware of the number of LO's prescribed for this level.

LO1 deals with the *scientific investigative process*. As expressed in the NSLA, it involves three steps: planning, doing, and reviewing. These three steps, covering the full investigative process, are the Assessment Standards for LO1 (see par. 4.6.2.1). The NSLA provides for activities aimed at building competence in LO1, by means of a set of process skills essential to outcomes-based science tasks (compare par. 4.6.3). For teachers, this implies the planning of science experiences which integrate the scientific process skills with the attitudes related to the scientific investigative process, as much as with the fundamental science concepts. An important finding from the empirical survey is that a significant percentage of teachers (44%) are *uncertain* whether they provide experiences for learners that cover the full scientific investigative process.

When a curriculum is defined in terms of *outcomes,* teachers are required to plan learning experiences with a view to achieving these outcomes. Teachers are in need of guidance and support in the planning of such Natural Science experiences.

- **Understanding and use of the scientific process skills** (see results for specific research problem 9, Chapter 5, and the list of process skills in Chapter 2, par. 2.5.3.2)

Literature in the field puts great stress on teaching the scientific process skills appropriate to young learners. Learners discover the content of science through the processes of scientific enquiry. LO1 (scientific investigation) can only be achieved when learners are provided with sufficient opportunity to engage in the scientific investigative process, and to gain intellectual control over the field through concept formation (see par. 4.6.3). Again, the role of the Foundation Phase teacher is crucial, as this level provides the basis for all further process skills acquisition. Teachers should understand and appreciate what the process skills involve, but should also know how to apply them in practice. Only then will they be able to facilitate the process of scientific enquiry (see par 4.6.3). It ought to be a cause of real concern that many South African teachers may not be familiar with either the concept of process skills, or their development (see par. 2.5.3.2). This concern was supported by the survey data, indicating that the majority of the Foundation Phase teachers do not know what the process skills (as set out in the NSLA) entail. Such teachers cannot effectively facilitate the process of investigation, resulting in the non-achievement of LO1 (scientific investigation).

- **Choice of suitable content** (see results for specific research problem 10, Chapter 5)

The content areas prescribed in the NSLA are Life and Living, Energy and Change, Planet Earth and Beyond, and Matter and Materials (see par. 4.6.4.1). The NSLA requires schools to ensure that all Foundation Phase learners receive science education covering the broad range of science knowledge and concepts from all four knowledge strands. Although LO1 focuses on the investigative process, it cannot be achieved in a vacuum, but requires a certain amount of content. The Foundation Phase teacher must therefore provide learning opportunities from all four content areas to ensure sufficient breadth in LO1. Developing learners' understanding of science concepts will improve their scientific literacy and their chances of becoming informed, responsible members of society. The teacher herself should possess the required background knowledge of the whole range of content areas.

Literature in the field warns that teachers lacking content knowledge and confidence, often attempt to minimise their difficulties by avoiding particular science topics. Furthermore, primary teachers are often likely to bring their own *misconceptions* into the classroom when dealing with topics they are not knowledgeable about (compare par.4.7.1 and 4.7.2.2). The conducted survey indicates a clear preference among

Foundation Phase teachers for the Biological sciences, while they are predominantly negative towards Physical sciences (including Matter and Materials and Energy and Change). A great concern is that teachers are unaware of the section in the NSLA dealing with these core knowledge and concepts.

The NSLA recognises the importance of context-related concept development. Foundation Phase teachers should make use of content from local contexts, which are more likely to be significant to learners and local communities (e.g. economic, environmental, social or health). The teachers participating in the survey indicated that they generally manage to draw the required 30% content from local contexts.

The difficulties of teachers in gaining sufficient content knowledge, are widely acknowledged in literature (par. 4.7.1). Nonetheless, it remains imperative that teachers should know more than the basics of the science content they teach. Foundation Phase teachers are required to amalgamate subject knowledge and knowledge about the learner. This requires considerable thought and experience on the part of the teacher. Suitable and adequate educational material is therefore crucial, especially to practising teachers lacking a basic science education.

- **Inhibiting factors in teaching Natural Science** (see results for specific research problem 13, Chapter 5)

Factors inhibiting the teaching of Natural Science are well documented (see par. 4.7.2.1 - 4.7.2.5). The conducted survey may contribute to the identification of similar factors limiting the quality of science in the South African Foundation Phase. A list, compiled from the responses of participating teachers, includes the following (arranged in order of priority):

(1) overcrowded curricula;
(2) inadequate teaching time;
(3) poor resourcing;
(4) inadequate curriculum resources;
(5) large classes;
(6) inadequate Learning Outcomes; and
(7) lack of knowledge and skills to teach science.

Addressing these issues will most certainly improve the quality of science education in South Africa.

6.2.4 Conclusions with regard to research objective 4 Personal perceptions and understandings of teachers in the Foundation Phase with regard to Natural Science learning and teaching

- **Past personal experiences and feelings** (see results for specific research problem 1, Chapter 5)

A recurring theme in literature is the possible negative effect of past personal experiences on teachers' attitudes towards science (see par. 1.2.1.3 and 2.5.3.3). Conversely, it may be assumed that teachers with positive personal experiences of the field in their own past, will be better motivated to teach science.

Somewhat surprisingly, it emerged from the questionnaire that teachers feel predominantly positive towards science, especially towards the Life sciences. While this should be regarded as encouraging, the sentiments expressed should be corrected by teachers' perceptions regarding their own level of scientific literacy, which is generally indicated to be low. The discrepancy suggests that teachers are comfortable with a small section of the field, but uncertain about their abilities in content areas apart from the Life sciences, and in other components of science education (compare conclusions relating to specific research problem 3).

- **Teachers' confidence regarding Natural Science education** (see results for specific research problem 2, Chapter 5)

Research suggests that teachers' lack of confidence regarding the presentation of Natural Science impacts negatively on the quality of science teaching (see par 4.7.2.2). It may be assumed that teachers' confidence and interest in teaching science will determine the frequency, the choice of content and the instructional strategies they employ in their teaching.

It appears from the survey as if South African teachers generally do not lack the confidence to teach science. While this result may be viewed as positive, it is again offset by teachers' perceptions of themselves as competent science teachers. The result of the survey regarding the latter is inconclusive: 51% of the participating teachers were *undecided* as to whether they are good science teachers (see results for specific research problem 2, question B15).

Literature in the field is adamant about the role of competent teachers in a quality science education programme (see par. 4.7). Competent science teachers will be able to facilitate the scientific investigative process effectively, draw content and concepts from the wide range of knowledge strands, and create an environment conducive to science learning.

How should the discrepancy between confidence on the one hand, and low self-estimate as science teachers on the other hand be interpreted? It appears as if the high level of confidence of teachers is limited to a particular content area, namely that of the Life sciences. It emerged from the survey that teachers display a distinct preference for content from the Life sciences, while lacking interest and confidence in the Physical sciences (see results for specific research problem 1 and 10). Teachers would in all probability tend to avoid the content areas in which they lack confidence. This might have the detrimental consequence that certain content areas are not taught on a regular basis, or even omitted altogether, leaving gaps in children's experiences from all the content areas.

- **Teachers' perceptions regarding their training** (see results for specific research problem 12, Chapter 5)

Proper teacher training (both pre- and in-service) cannot be overemphasised (see par. 4.7). For South African Foundation Phase teachers, a diploma or degree in Early Childhood Development/Foundation Phase teaching is usually required. In such general training, solid grounding in specific subject areas is often lacking. Of the teachers participating in the survey, 50% did not take Natural Science as a module during their teacher training. Furthermore, 53% of teachers indicated that they acquired their content knowledge through self-study, which may imply insufficient understanding of the broad field of science. Teacher training institutions should be urged to include adequately preparation in their syllabi to equip Foundation Phase teachers for the complex task awaiting them.

With regard to in-service training, the survey indicated that 57% of the teachers are in need of more training on the NSLA, and 81% would like to have science curriculum resources. Foundation Phase teachers should be afforded the opportunity to update their knowledge and skills through ongoing professional development and in-service training.

6.3 RECOMMENDATIONS

Scientifically literate citizens are invaluable to the social and economical well-being of a country. Scientific literacy as an outcome for learners has the potential of improving the quality of life of all South Africans. This stated outcome of the Natural Science Learning Area cannot be achieved without quality science education. Ironically, this is especially true for the neglected Foundation Phase level, which lies at the basis for all subsequent success in science learning.

Resulting from the investigation, findings and conclusions of this study, some recommendations for improving the quality of science education in the Foundation Phase are now presented.

Recommendation 1: Establish Natural Science education as a national priority

It is important that policy makers at national level recognise the significance of science education and its fundamental role in developing scientific literacy among the population. A shift towards prioritising the promotion of scientific literacy, especially among young learners, needs to be accomplished. All stakeholders should be involved in furthering this aim. State departments as well as the private sector should be encouraged to provide support by means of resource provision, adequate funding and furthering the desired outcome of scientific literacy for all South African citizens.

Steps need to be taken to lift the profile of Natural Science education in policy documents. It is the opinion of the researcher that the Natural Science Learning Area should be established as one of the core Learning Areas in the Foundation Phase. If this is not possible, an increase in the number of Learning Outcomes for Natural Science would send the message that Natural Science education is regarded as a high priority in South Africa. Additionally, clear guidelines should be formulated with regard to time allocation for Natural Science teaching in schools on all levels. Provincial districts should follow-up on these guidelines to ensure that adequate Natural Science education takes place in every Foundation Phase classroom.

Recommendation 2: Invest in teacher training

It cannot be emphasised enough that teachers hold the key to the successful implementation of the NSLA. The power for improvement lies within the teaching profession. Only high quality, appropriate teacher training with sufficient focus on Natural Science education, will facilitate the promotion of scientific literacy. Training programmes should equip Foundation Phase teachers with adequate knowledge and skills in content, curriculum requirements, and in appropriate methodologies for Foundation Phase learners.

Natural Science teaching in an outcomes-based paradigm and an integrated curriculum places considerable demands on the teacher, as it requires sophisticated skills. Furthermore, the difficulties and constraints relating to theoretical understanding, time, administrative support, resources and curriculum requirements are considerable. It is therefore essential that teachers receive ongoing support in keeping up with new developments in various aspects of science teaching: developments in the field of science itself, in science education and how children learn science, and in facilitating the development of scientific literacy within an outcomes-based paradigm. Scientific literary must become the key concept in the training of student teachers and in-service practising teachers alike.

Recommendation 3: Provide curriculum guidelines and resources

Schools cannot teach Natural Science effectively without the necessary conditions and resources. These do not necessarily entail expensive equipment. More importantly, schools and teachers should have access to proper information. The National Department of Education and/or the provincial departments should provide at least the following:

- quality curriculum guidelines for teachers needing assistance in translating the outcomes-based NSLA into classroom practice;
- adequate training material for teachers lacking a proper science education background;
- curriculum guidelines with ideas for appropriate themes, pre-planned lessons, integration possibilities, suitable methods, ways of assessment, and so forth;
- on-line resources that are updated continuously for teachers with access to the Internet.

Teachers should realise that sophisticated science equipment is not essential to teach science effectively: appropriate science resources can be found from nature and from everyday surroundings. School communities should also be urged to get involved in providing developmentally appropriate science resources.

Recommendation 4: Establish leadership and collaboration

Proper leadership with regard to Natural Science education can contribute immensely to effective science teaching in schools. The Head of Department or semi-specialist (Natural Science/Foundation Phase teacher) can take up the role as mentor to provide support in terms of collaborative teacher planning, ideas for teaching, motivation to increase confidence, evaluation and improvement.

Schools collaborating in the field of science are more likely to make a positive impact. An inter-school collaborative network may include workshops, networking, sharing of ideas, visits from experts in the field, and so forth. Schools may also collaborate to establish a "library for science resources" that can be shared across school boundaries.

Teachers within the same school should be encouraged to work together. A crucial aspect of collaboration within the same school, is to ensure gradual progression across the grades.

Recommendation 5: Further investigation

From the present study, various areas requiring further investigation have emerged:

- Further research should complement this study by including qualitative data gathering methods such as interviews. These would be important in order to establish teachers' understanding of important concepts such as scientific literacy. Observations in classroom settings would provide information regarding the actual picture of Natural Science education in Foundation Phase classrooms.

- Future research could replicate the empirical aspect of this study, but broaden the parameters set here. For instance, the questionnaire may be made available in all the official languages, or be distributed among a wider range of communities and regions as was presently the case. A wider sample will produce findings more representative of the country as a whole.

- A survey to determine learner competence in LO1 (Scientific investigation) could also be conducted.

6.4 FINAL WORD

In conclusion, it may be stated that the research hypothesis is to a large degree supported by the evidence presented in the study. While significant variety should be allowed for, the current condition of Natural Science teaching at the Foundation Phase may not be regarded as sufficiently healthy. Even though the situation in South African schools is not altogether desperate, much room for improvement exists. Some areas which need improving have been identified and discussed. It appears that current training programmes and policy documents indeed recognise the importance of adequate Natural Science teaching in the Foundation Phase, but often not to a sufficient degree. Frequently, a huge gap exists between the aims of policy documents and actual practice. Teachers are in general positive about the Natural Science Learning Area, but are often ignorant and uncertain about what is required of them. The priority given to science teaching during the crucial Foundation Phase needs to be lifted, and the support given to teachers needs to be enhanced.

The world we are living in places particular demands on individuals, demands that need to be addressed and for which planning is needed. Scholarly literature, from both developing and developed countries, stresses the importance of scientific literacy among populations. This demand needs to be reflected in national educational priorities, from where it should lead to proper emphases in policy and curriculum documents, and teacher training programmes. Science teaching in the Foundation Phase is where it all starts. We cannot afford to neglect the foundations laid during this crucial educational phase. The researcher hopes that the present study will contribute to a better understanding of what good Natural Science education at this level entails, and will provide some pointers for the direction to be taken in future.

BIBLIOGRAPHY

Akerson, V.L. 2001. Teaching Science When Your Principal Says "Teach Language Arts". *Science and Children* (April 2001), 42-45.

American Association for the Advancement of Science (AAAS). 1989. *Science for all Americans*: Benchmarks for scientific literacy, available online at: http://www.aaas.org/project2061/ (accessed 2006/03/22).

Appleton, K and Kindt, I. 1999. Why teach primary science? Influences on beginning teacher's practices. *International Journal of Science Education* 21(2),155-168.

Arkansas Science Teachers Association (ASTA). The Nature of Science and Scientific Theories. Nature of Science, Theories & Evolution, available online at: http://www.aristotle.net/~asta/science.htm, (accessed 2003/04/30).

Aram, R. and Bradshaw, B. 2001. How do children know what they know? *Science and Children* 39(2), 29-33.

Asoko, H. 2000. Learning to teach science in the primary school, in Millar, R. Leach, J. and Osborne, J. (Eds). 2000. *Improving Science Education: The Contribution of Research*. Philadelphia: Open University Press.

Atkinson, S. and Fleer, M. 1995. *Science with Reason*. London: Hodder & Stoughton.

Australian Curriculum Framework. Curriculum Council, Government of Western Australia. Curriculum Framework - Science: The scope of the curriculum, available online at:http://curriculum.wa.edu.au/pages/framework/framework09c.htm (accessed 2005/02/17).

Bauer, H. 1996. Scientific Literacy is Child's Play. *Intercultural Development Research Association (IDRA) Newsletter* (April 1996), available online at: http://www.idra.org?Newslttr/1996/Apr/Bauer.htm (accessed 2004/05/03).

Baxter, L.M. and Kurtz, M.J. 2001. When a hypothesis is NOT an educated guess: Clarifying the language of science. *Science and Children* 38(7), 8-20.

Bently, M. Ebert, C. and Ebert II, E.S. 2000. *The Natural Investigator: A Constructivist Approach to Teaching Elementary And Middle School Science.* Wadsworth: Thomson Learning.

Beute, N. and Mvalo, G. Challenges facing science and technology in Southern Africa, available online at: http:/www.tu-bs.de/institute/ATD/icte2000/beute.pdf (accessed 2003/04/23).

Bickart, T.S., Jablon, J.R. and Dodge, D.T. 1999. *Building the Primary Classroom: A Complete Guide To Teaching and Learning*. Washington, DC: Teaching Strategies, Inc.

Blankley, W. and Arnold, R. 2001. Public understanding of science in South Africa: Aiming for better intervention strategies. Science education. *South African Journal of Science* 97, 65-69.

Brandscombe, N.A., Castle, K., Dorsey, A.G. and Taylor, J.B. 2003. *Early Childhood Curriculum: A Constructivist Perspective*. Boston: Houghton Mifflin.

Bredekamp, S. and Rosegrant, T. (Eds.) 1992. *Reaching Potentials: Appropriate Curriculum and Assessment for Young Children* (Vol 1). Washington, DC: National Association for the Education of Young Children.

Bybee, R.W. 1997. *Achieving Scientific Literacy: From Purposes to Practical Action*. Portsmouth, NH: Heinemann.

Carin, A.A. and Bass, J.E. 2001. *Teaching Science as Inquiry* (9^{th} ed.). New Jersey: Prentice-Hall.

Casacanada, Naturalistic Intelligence, available online at: http://www.casacanada.com/natuintel.html (accessed 2004/04/23).

Catholic Encyclopaedia, art. 'Positivism', available online at: http://www.newadvent.org/cathen/12312c.htm (accessed 2004/05/07).

Centre For Development and Enterprise Research Report no 13, November 2004. From Laggard to World Class: Reforming maths and science education in South Africa, available online at: www.cde.org.za (accessed 2005/05/23).

Chaillé, C. and Britain, L. 2003. *The Young Child as Scientist: A Constructivist Approach to Early Childhood Science Education* (3^{rd} ed.). Boston: Allyn and Bacon.

Charlesworth, R. and Lindt, K. K. 2003. *Maths and Science for Young Children* (4^{th} ed.). New York: Thomson Delmar Learning.

Colburn, A. 2004. Inquiring Scientists Want to Know. *Educational Leadership* 62(1), 63-66.

Curriculum Council, Government of Western Australia. Curriculum Framework - Science: Definition and Rationale, available online at: http://curriculum.wa.edu.au/pages/framework/framework09a.htm (accessed 2003/04/30).

Curtis, D. 2002. The Power of Projects. *Educational Leadership* 60 (1), 50-53.

Darling-Hammond, L. 1997. *Doing what Matters Most: Investing in Quality Teaching*. New York: National Commission on Teaching and America's Future.

Day, B. 2003. Chairperson, SASOL Science Festival Grahamstown.

De Boer, G.E. 1991. *A History of Ideas in Science Education: Implications for Practice*. New York: Teacher College Press.

De Jager, T. and Ferreira, J. G. 2003. Factors preventing the development of process skills of biology secondary school learners in South Africa. *Educare* 32(1&2), 186-198.

De Vos, A.S. (ed.) 1998. *Research at Grass Roots. A Primer for the Caring Professions*. Pretoria: Van Schaik.

Department of Education. 2001. Education White Paper 5 on Early Childhood Development. South Africa. Pretoria: Government Printers.

Department of Education (a). 2002. *Revised National Curriculum Statement Grades R-9. Overview*. South Africa. Pretoria: Government Printers.

Department of Education (b). 2002. *Revised National Curriculum Statement Grades R-9. Natural Science Learning Area Statement*. South Africa. Pretoria: Government Printers.

Department of Education 2003. *Revised National Curriculum Statement Grades R-9 (Schools). Teacher's Guide for the Development of Learning Programmes. Foundation Phase.* South Africa. Pretoria: Government Printers.

Department of Education/Gauteng Institute for Educational Development (DoE/GIED). 2002. *C2005. Revised National Curriculum Statement Grades R-3 (Foundation Phase).* Pretoria: Government Printers.

Dryden, G. and Vos, J. 2001. *The Learning Revolution: To Change the Way the World Learns*. Stafford: Network Educational Press.

Dyasi, H. 1999. *What Children gain by Learning through Inquiry*. Foundations 2, Enquiry. Arlington: National Science Foundation.

Edwards, L.C. 2000. *The Creative Arts: A Process Approach for Teachers and Children* (3rd ed.). New Jersey: Prentice Hall.

Eggen, P. and Kauchak, D. 1994. *Educational Psychology: Classroom Connections*. New York: Merrill.

Encarta 97 Encyclopaedia, art. 'Science'.

Encarta Encyclopaedia Standard 2004 (Microsoft), art. 'Science'.

Eshach, H. and Fried, N. 2005. Should science be taught in early childhood? *Journal of Science and Technology* 14(3), 315-336.

Esler, W.K. and Esler, M.K. 2001. *Teaching Elementary Science: A Full-Spectrum Science Instruction Approach* (8th ed.). Belmont: Wadsworth/Thomson Learning

Etheregde, S. and Rudnitsky, A. 2003. *Introducing Students to Scientific Inquiry: How do We know What We know?* Boston: Allan and Bacon.

Fleer, M. and Hardy, T. 1996. *Science for Children. Developing a Personal Approach to Teaching*. Sydney: Prentice Hall.

Fleer, M. and Hardy, T. 2001. *Science for Children. Developing a Personal Approach to Teaching* (2nd ed.). Sydney: Prentice Hall.

FortuneCity. Ways of approaching research: Quantitative Designs, available online at: http://www.fortunecity.com/greenfield/grizzly/432/rra2/htm (accessed 2003/04/23).

Fouché, C.B. 1998. 'Data collection methods', in De Vos (ed.) 1998:152-177.

Fouché, C.B. and De Vos, A.S. 1998. 'Selection of a research design', in De Vos (ed.) 1998:122-137.

Frank, L. (Jr.) 2001. Standardizing the language of inquiry: Using the precise language of science can help teachers develop students' science-process skills. *Science and Children* 38(5), 38-40.

Frost, J. 1997. *Creativity in Primary Science*. Buckingham: Open University Press.

Gauteng Department of Education/University of South Africa (GDE/UNISA)(1). 2003. *Training Manual: Revised National Curriculum Statement (Foundation Phase)*. Book 1. Pretoria: Gauteng Provincial Government.

Gauteng Department of Education/University of South Africa (GDE/UNISA)(2). 2003. *Training Manual: Revised National Curriculum Statement (Foundation Phase)*. Book 2. Pretoria: Gauteng Provincial Government.

Gauteng Department of Education/University of South Africa (GDE/UNISA)(3). 2003. *Training Manual: Revised National Curriculum Statement (Foundation Phase)*. Book 3: Learning Programmes. Pretoria: Gauteng Provincial Government.

Gega, P.C. 1994. *How to teach Elementary School Science* (2nd ed.). New York: Macmillan

George Mason University Graduate School of Education 2003.Advanced Organizer, available online at: http://chd.gse.gmu.edu/immersion/knowledgebase/strategies/cognitivism/AdvancedOrganizers.htm (accessed 23/04/2004).

Goodrum, D., Hackling, M. and Rennie, L. 2001.The status and quality of teaching and learning science in Australian schools. Research report prepared for the Department of Education, Training and Youth Affairs. DEST. Commonwealth Department of Eduation, Science and Training, available online at: http://www.dest.gov.au.schools/publications/2001/science/chap1.htm (accessed 2005/02/17).

Gray, B., Naidoo, P. and Savage, M. 2004. Why a Different Book?, in African Forum for Children's Literacy in Science and Technology (AFCLIST), School Science in Africa, 2004. *Learning to Teach, Teaching to Learn*. Lansdowne:Juta Gariep.

Grayson, D. 2001. Long-term improvement in maths and science achievement. *Sunday Times* 2001/9/23.

Gricorenco, E.L. 1998. Mastering tools of the mind in school (Trying out Vygotsky's ideas in classroom), in Carin, A.A. and Bass, J.E. 2001. *Teaching Science as Inquiry* (9th ed.). New Jersey: Prentice-Hall.

Hayton, M. Science in early childhood, in Atkinson, S. and Fleer, M. 1995. *Science with Reason*. London: Hodder & Stoughton.

Harlan, J.D. and Rivkin, M. S. 2000. *Science Experiences for the Early Childhood Years: An Integrated Approach (*7th ed.). Upper Saddle River: Merrill.

Harlen, W. 2000. *The Teaching of Science in Primary Schools* (3rd ed.). London: David Fulton Publishers.

Helm, J.H. 2004. Projects that power young minds. *Educational Leadership* 62 (1), 58-62.

HIGH/SCOPE Educational Research Foundation. Educational programs, available at: http://www.highscope.org/EducationalPrograms/Elementary/environment.htm (accessed 2004/04/23).

Hobden, J. 2000. Views on the 'right kind of teacher' for science 3-13, in Warwick, P. and Sparks Linfield, R. (Eds.) 2000. *Science 3-13: The Past, the Present and Possible Futures*. London: Routledge.

Hopkins, W.G. Qualitative research design, available online at: http://www.sportsci.org/jour/0001/wghdesign.html. (accessed 2005/09/19).

Howe, A.C. How students learn science: Ideas from a Russian psychologist. *Minds on Science Gazette* 2, available online at: http://scied.gsu.edu/Hassard/mos/howe.html (accessed 2003/04/03).

Howie, S. J. 1999. Challenges to reforming science education in South Africa: What do the Third International Mathematics and Science Study results mean? *Science and Environment Education: Views from Developing Countries,* available online at: http://www1.worldbank.org/education/scied/documents/Ware/Ware1999.htm (accessed 2003/06/05).

Human Sciences Research Council of South Africa (HSRC) (a). Research Programmes: TIMSS-R, available online at:
http://www.hsrc.ac.za/research/timms/timms03.html (accessed 2005/06/02).

Human Sciences Research Council of South Africa (HSRC) (b). Research Programmes: TIMSS 2003, available online at:
http://www.hsrc.ac.za/media/2004/12/20041214_1.html (accessed 2005/06/02).

Huysamen, G.K. 1993. *Metodologie vir die Sosiale en Gedragswetenskappe*. Pretoria: Sigma.

Infed. Encyclopaedia Archives, art. 'Howard Gardner, multiple intelligence and education', available online at: http://www.infed.org/thinkers/gardner.htm (accessed 2004/04/23).

Jeans, B. and Farnsworth, I. 1992. Primary science education: Views from three Australian states. *Research in Science Education* (22):214-223.

Jeans, B. and Farnsworth, I. 1996. Elementary Science Education in Australia. Unpublished paper presented at the annual conference of the Australian Science Education Research Association (Canberra).

Johnston, J. 1996. *Exploring Primary Science and Technology: Early Explorations in Science*. Buckingham: Open University Press.

Katz, L.G. and Chard, S.C. 1999. *Engaging children's minds: The project approach* (2nd ed.). Stamford, CT: Ablex Publishing

Kanjee, A. Grade 6 Systematic Evaluation, (HSRC), available online at:
http://www.hsrc.ac.za/research/projectDetail.php?group=ESSD&bYear=2005/06&pN...
(accessed 2006/15/03).

Kearsley, G. The Theory into Practice Database (TIP). Conditions of Learning, available online at: http://tip.psychology.org/gagne.html (accessed 2004/04/23).

Leedy, P.D. 1997. *Practical Research: Planning and Design* (6th ed.). New Jersey: Prentice Hall.

Lincoln, Y. and Guba, E. 1985. *Naturalistic Inquiry*. Beverly Hills: Sage.

Lindt, K. 2000. *Exploring Science in Early Childhood Education: A Developmental Approach* (3rd ed.). Wadsworth: Thomson Learning.

Lorsbach, A. and Tobin, K. 1997. Constructivism as a referent for science teaching, available online at: http://www.exploratorium.edu/ifi/resources/research/constructivism.html (accessed 2006/03/08).

Lowery, L. 1998. How new science curriculums reflect brain research. *Educational Leadership* (November 1998), 26-30.

Mangena, M. 2002. Address as Deputy Minister of Education, available online at: http://education.pwv.gov.za/Media/mangena/Jan2002/bostec.htm (accessed 2004/03/06).

Marek, E.A. and Cavallo, A.M.L. 1997. *The Learning Cycle: Elementary School Science and Beyond* (Revised ed.). Portsmouth, NH: Heinemann.

Martin, R.E. (Jr.), Sexton, C., Wagner, K. and Gerlovich, J.1994. *Teaching Science for All Children*. Boston: Allyn and Bacon.

Martin, D.J. 2001. *Constructing Early Childhood Science*. Wadsworth: Thomson Learning.

Martin, D.J. 2003. *Elementary Science Methods: A Constructivist Approach* (3rd ed.). Wadsworth: Thomson Learning.

McIntyre, M. 1984. *Early Childhood and Science.* Washington, D.C: National Science Teachers Association.

McLean, M. 2004. Art. 'Curriculum', in Encarta Encyclopaedia Standard 2004 (Microsoft).

Millar, R. Leach, J. and Osborne, J. (Eds). 2000. *Improving Science Education: The Contribution of Research*. Philadelphia: Open University Press.

Morrison, I. and Webb, L. 2000. Science 3-13 and the National Curriculum in Science 3-13, in Warwick, P. and Sparks Linfield, R. (Eds.) 2000. *Science 3-13: The Past, the Present and Possible Futures*. London: Routledge.

Mouton, J. 2001. *How to Succeed in your Master's and Doctoral Studies: A South African Guide and Resource Book*. Pretoria: Van Schaik.

Murphy, C., Beggs, J., Hickey, I., O'Meara, J., Sweeney, J. 2001. National Curriculum: Compulsory school science - Is it improving scientific literacy? *Educational Research* 43 (2), 189-199.

Muwanga-Zake, J.W.F. 2003. Is science education in a crisis? Some of the problems in South Africa. *Science in Africa* (2), available online at: http://www.scienceinafrica.co.za/scicrisis.htm (accessed 2003/05/06).

News24.com 2005. Grade 6 kids 'not making it', available online at: http://www.news24.com/News24/South_Africa/News/0,,2-7-1442_1849666,00.html (accessed 2006/02/28).

Newton, L.D. 2005. Introduction: Improving primary science teaching, in Wenham, M. 2005. *Understanding Primary Science: Ideas, Concepts and Explanations* 2nd ed.). London: Paul Chapman.

Nukeri, H.J. 2000. *An Intervention Programme to Promote the Choice of Physical Science by Secondary School Learners*. Unpublished doctoral thesis, Pretoria: University of South Africa.

OECD Programme for International Student Assessment. 1999. *Measuring Student Knowledge and Skills: A New Framework for Assessment*. Paris: OECD

O'Donoghue, R. 2004. Marrying indigenous and western science through environmental education, in African Forum for Children's Literacy in Science and Technology (AFCLIST), School Science in Africa, 2004. *Learning to Teach, Teaching to Learn*. Lansdowne: Juta Gariep.

Ollerenshaw, C and Ritchie, R. 1997. *Primary Science: Making it Work*. London: David Fulton.

Organisation of Economic Cooperation and Development: Programme for International Student Assessment, 1999 (OECD/PISA), in Goodrum, D., Hackling, M. and Rennie, L. 2001.*The Status and Quality of Teaching and Learning Science in Australian Schools*. Research Report, available online from http://www.dest.gov.au.schools/publications/2001/science/chap2.htm (accessed 2005/02/17).

Osborne, J. 1995. Science from a child's perspective in Atkinson, S. and Fleer, M. 1995. *Science with Reason*. London: Hodder & Stoughton.

Osborne, R. and Freyberg, P. (1985) 2001. *Learning in Science: The Implications of Children's Science*. Hong Kong: Heineman.

Ovens, P. 2000. *Reflective Teacher Development in Primary Science*. London: Falmer Press.

Pandor, N. 2004. Results of 2003 trends in Mathematics and Science Study (TIMSS), available online at: http://www.info.gov.za/speeches/2004/041215091004.htm (accessed 2005/02/06).

— 2006. Tell no lies: Grade 6 evaluation. *Mail&Guardian* 24 January 2006, available online at:
http://www.mg.co.za/articlePage.aspx?articleid=262206&area=/the_teacher/teacher_f... (acessed 2006/02/28)

Parker, S.P. (ed.) 1998. *McGraw-Hill Concise Encyclopedia of Science & Technology.* New York: McGraw-Hill.

Plourde, L. A. 2002. Elementary Science education: The influence of student teaching - where it all begins. *Education*123(2), 253-259.

Potenza, E. 2000. The debate about the curriculum is just beginning. *Sunday Times* 27/2/2000.

Prime Minister's Science, Engineering and Innovations Council (PMSEIC). 1999. *Raising Awareness of the Importance of Science and Technology to Australia's Future* (Paper prepared by an independent working group for PMSEIC).

Qualter, A. 1996. *Exploring Primary Science and Technology: Differentiated Primary Science*. Buckingham: Open University Press.

Rademeyer, A. Swak wiskunde, wetenskap strem swart vooruitgang. *Beeld* 2004/12/15.

Rainworth, B. and Kugelmass, J.W. 2003. *Curriculum Instruction for All Learners: Blending Systematic and Constructivist Approaches in Inclusive Elementary Schools.* Baltimore: Paul H. Brookes.

Roehler, L.R. and Cantlon, D.J. 1997. Scaffolding: A powerful tool in social constructivist classrooms, in Carin, A.A. and Bass, J.E. 2001. *Teaching Science as Inquiry* (9th ed.). New Jersey: Prentice-Hall.

Routman, R. 1991. *Invitations: Changing as teacher and learners K - 12*. Portsmouth, N.H.:Heineman

Savage, M., Naidoo, P. & Gray, B. 2004. Implementing the goals of science education and supporting change, in African Forum for Children's Literacy in Science and Technology (AFCLIST), School Science in Africa, 2004. *Learning to Teach, Teaching to Learn*. Lansdowne: Juta Gariep.

Searson, R. and Dunn, R. 2001. The learning-style teaching model. *Science and Children* (February 2001), 22-26.

Schultze, S. and Nukeri, H.J. 2002. An intervention programme to promote the choice of physical science by secondary school learners. *Educare* 31 (1&2), 153-174.

Sharp, J.G. and Grace, M. 2004. Anecdote, opinion and whim: Lessons in curriculum development from primary science education in England and Wales. *Research Papers in Education* 19 (3), 294-321.

Smith, E.L. 1991. A conceptual change model, in Glynn, S.M., Yeany, R.H. and Britton (Eds.), *The Psychology of Learning*. New York: Lawrence Erlbaum Associates.

Summers, M. and Mant, J. 1995. A survey of British primary school teachers' understanding of the earth's place in the universe. *Educational Research* 37(1), 3-19.

Supporting science teachers: A snapshot of science in schools, available online at: www.dest.gov.au/schools/publications/2001/science/ondex.htm (accessed 2003/08/30).

Szesze, M. 2001. MCPS Science. Teaching using the 5 E's, available online at: http://www.mcps.k12.md.us/curriculum/science/instr/teaching5Es.htm (accessed 24/08/2005).

Telkamp, D.K. Learning and Cognition, available online at: http://mercury.sfsu.edu/ching/personal/Learning/theorists/ausubel.htm (accessed 2004/04/23).

Tomei, L. Learning theories - A Primer Exercise. An Examination of Cognitivism: The Psychology of Knowledge and Strategies, available online at: http://academics.rmu.edu/~tomei/ed711psy/c_ausub.htm (accessed 2004/04/23).

Tytler, R. 2004. Windows into practice: Constructing effective science teaching and learning in a school change initiative. *International Journal of Science Education* 26(2), 171-194.

University of Pittsburgh, Developmental psychology in Science Ed., available online at: http://www.pit.edu/~vtalsma/syllabi/2943/handouts/DEV_Psych.html (accessed 2003/04/03).

Van der Horst, H. and McDonald, R. 2003. *Outcomes-based Education: Theory and Practice*. Pretoria: Tee Vee Printers.

Van Staden, C.J.S. 2002. *Emergent Science.* Study Guide for Reception Year Certificate Course. Part B, Module 3. Pretoria: Unisa Press.

Van Staden, C.J.S. 2003. *Science and Technology*. Only Study Guide for PRS402-D & PCF408-8. Pretoria: Unisa Press.

Victor, E. and Kellough, R.D. 2000. *Science for the Elementary and Middle School* (9^{th} ed.). New Jersey: Prentice Hall.

Vygotsky, L.S. 1962. *Thought and Language*. Cambridge, MA: MIT Press.

Ward, H., Roden, J., Hewlett, C. and Foreman, J. 2005. *Teaching Science in the Primary Classroom: A Practical Guide*. London: Paul Chapman.

Ware, S. 1999. Science and environment education: Views from developing countries, available online at: http://www1.worldbank.org/education/scied/documents/Ware/Ware1999.htm (accessed 2003/05/06).

Warwick, P. and Sparks Linfield, R. (Eds.) 2000. *Science 3-13: The Past, the Present and Possible Futures*. London: Routledge.

Watt, D. and Simon, S. 1999. Textual support for primary science teaching? *The Curriculum Journal* 10(3), 385-401.

Wenham, M. 1995. *Understanding Primary Science: Ideas, Concepts and Explanations*. London: Paul Chapman.

Western Cape Education Department (WCED) (Directorate: Curriculum Development) 2003. *Revised National Curriculum Statement. Learning Area: Natural Science (Foundation Phase Grades R to 3)* Resource Material.

Western Cape Provincial Government. 2005. WCED task team to drive numeracy and literacy strategies (unpublished).

Wilson, L.O. 1997. The Eighth Intelligence: Naturalistic Intelligence, available online at http://www.uwsp.edu/education/lwilson/learning/natintel.htm (accessed 2004/04/23).

Winebrenner, S. 1996. *Teaching Kids with Learning Difficulties in the Regular Classroom: Strategies and Techniques Every Teacher Can Use to Challenge & Motivate Struggling Students*. Minneapolis: Free Spirit Publishing.

Wolfinger, D.M. and Stockard, J.W. (Jr.) 1997. *Elementary Methods: An Integrated Curriculum*. New York: Longman.

Wood, G. Area Education Agency. About Project 2061, available online at: http://www.aea10.k12.ia.us/curr/science/science/AAAS.html (accessed 2005/06/03).

APPENDIX A

011 3550512

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Date:	20 August 2005
Name of Researcher:	Bosman Linda
Address of Researcher:	44 Kaptein Jan Street
	Rietondale
	0084
Telephone Number:	(012) 3296739
Fax Number:	(012) 4205595
Research Topic:	The Value, Place and Method of Teaching Natural Science in the Foundation Phase
Number and type of schools:	Primary & Secondary Schools
District/s/HO	Tshwane North & South

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*

APPENDIX B

University of Pretoria
School of Teacher Training
Department of Early Childhood Education

Dear Principal and Foundation Phase Teachers

<u>Completion of research-questionnaires</u>

As part of a research project on the Natural Science Learning Area, I have developed a questionnaire to determine the perceptions of **Foundation Phase teachers** on the *value, place and method of teaching Natural Science in the Foundation Phase*. The contribution and honest response of teachers in the field are important to the success of this research.

Confidentiality of information is guaranteed. The research is done on an anonymous basis and all information will be handled in a confidential manner. **No school or person will be identified**.

Your cooperation in the completion of the questionnaire/s is much appreciated. You are kindly requested to complete the questionnaires as soon as possible (±3 days after delivery). I will collect the questionnaires from your school on the date given on the envelope.

Permission for this research was granted by the Gauteng Department of Education - please see letter attached.

Thank you for your time and assistance!

Yours sincerely,

Mrs L Bosman
ECD/FP Lecturer, University of Pretoria
30 August 2005

Contact details:

Tel: (012) 329 6739 (H)
Cell: 082 566 2069

E-mail: linda.bosman@up.a.za

APPENDIX C: ENGLISH

RESEARCH QUESTIONNAIRE.

Dear teacher, the aim of this research is to determine your perceptions on the value, place and method of teaching Natural Science in the Foundation Phase. Your contribution as a teacher in the field is important to the success of this research. Your honest response will be much appreciated. Please do not write your name anywhere. Results obtained will only be reported on collectively.

NUMBER OF QUESTIONNAIRE			

3

SECTION A: Biographic and Demographic Information.

Please indicate your response by writing the relevant number in the square provided.

(A1) Your Age

30 years and younger = 1	Older than 31 = 2	

4

(A2) Highest Academic/Professional Qualification

Teacher's Diploma (3years) = 1 Higher/Further Teacher's Diploma = 2 Other = 5 (Specify ....)	Baccalaureus Degree = 3 Baccalaureus Educationis = 4	

5

(A3) Years experience as teacher in the Foundation Phase

Less than 8 years = 1	9 years or more = 2	

6

(A4)The grade you are currently teaching in

Grade R = 1	Grade 1 = 2	Grade 2 = 3	Grade 3 = 4	

7

(A5) Type of school you are teaching at

State school = 1 Other = 3 (Specify ....)	Private school = 2	

8

(A6) Language of instruction

Afrikaans = 1 Other = 3 (Specify ....)	English = 2	

9

(A7) Your province

Gauteng = 1 KwaZulu-Natal = 2 Mpumalanga = 3	North West = 4 Limpopo = 5 Free State = 6	Western Cape = 7 Eastern Cape = 8 Northen Cape = 9	

10

SECTION B

For the following part of the questionnaire, please indicate your level of agreement with the statements by marking the applicable square with a cross ✘.

Use the following scale:

1:Strongly disagree	**2:Disagree**	**3:Neutral/Undecided**	**4:Agree**	**5:Strongly agree**	**6:N/A**

TO RECALL YOUR PAST PERSONAL EXPERIENCES regarding science, please indicate your level of agreement with the following statements.

(B1)I can recall specific positive experiences in science class during High School	1	2	3	4	5	6
(B2)Biology was one of my favourite subjects when I was in High School	1	2	3	4	5	6

12

(B3)I had fun with science during Primary School	1	2	3	4	5
(B4)I like science	1	2	3	4	5
(B5)In general, I feel positive about science	1	2	3	4	5
(B6)I find science difficult	1	2	3	4	5
(B7)I view myself as a scientifically literate person	1	2	3	4	5
(B8)Science help us deal with our daily problems	1	2	3	4	5
(B9)I feel most comfortable with Biological Science (plants, animals, etc)	1	2	3	4	5
(B10)I prefer Physical Science (machines, electricity, etc)	1	2	3	4	5
(B11)Earth and Space Sciences are my favourite science topics	1	2	3	4	5
(B12)When I was at school, girls were encouraged less than boys in science class	1	2	3	4	5

22

INDICATE HOW YOU FEEL ABOUT PRESENTING NATURAL SCIENCE

(B13)I find it difficult to teach science	1	2	3	4	5
(B14)I like presenting science-related topics/themes/activities in my classroom	1	2	3	4	5
(B15)I am a good science teacher	1	2	3	4	5
(B16)I feel comfortable answering Foundation Phase learners' questions on science	1	2	3	4	5
(B17)I feel confident about my abilities to teach science to Foundation Phase learners	1	2	3	4	5
(B18)I lack the knowledge and skills to teach Natural Science effectively	1	2	3	4	5
(B19)I believe that science should be taught by a specialist teacher	1	2	3	4	5

29

INDICATE YOUR VIEW OF THE NATURE OF SCIENCE

(B20)I believe that science consist of facts, concepts and theories that have to be taught in the classroom	1	2	3	4	5
(B21)Science in the Foundation Phase equals doing experiments	1	2	3	4	5
(B22)I feel that Foundation Phase learners can learn many important values and attitudes through science	1	2	3	4	5
(B23)I believe that science is part of our everyday life	1	2	3	4	5

33

INDICATE YOUR VIEW OF THE ABILITIES OF FOUNDATION PHASE LEARNERS TO LEARN SCIENCE

(B24)I believe that all Foundation Phase learners are natural scientists	1	2	3	4	5
(B25)I think that all Grade R-3 learners can learn science	1	2	3	4	5
(B26)I believe science is too difficult for some Foundation Phase learners	1	2	3	4	5
(B27)Children can lead happy, useful lives without being scientifically literate	1	2	3	4	5

37

METHOD OF TEACHING NATURAL SCIENCE

(B28)I know how learners learn science best	1	2	3	4	5
(B29)I provide opportunities for learners to do practical work in science	1	2	3	4	5
(B30)I try to provide opportunities for learners to construct their own knowledge and understanding of science	1	2	3	4	5
(B31)I think that science knowledge is best acquired through rote-learning (memorisation)	1	2	3	4	5

1:Strongly disagree	2:Disagree	3:Neutral/Undecided	4:Agree	5:Strongly agree

(B32)I am aware of the teaching method most suitable for Natural Science in the Foundation Phase	1	2	3	4	5
(B33)I try to establish each learner's prior knowledge before I teach new science content	1	2	3	4	5
(B34)I mainly use worksheets to assess learner performance in science	1	2	3	4	5
(B35)I provide opportunities for learners to learn science by doing hands-on science	1	2	3	4	5
(B36)I am skilled at promoting critical thinking and problem-solving in science	1	2	3	4	5
(B37)I provide ample opportunities for learners to work with concrete materials in science	1	2	3	4	5
(B38)I provide ample opportunities for learners to share their science experiences in class	1	2	3	4	5
(B39)I mainly transmit science knowledge through telling the learners about science	1	2	3	4	5
(B40)I think group work is essential for effective science learning	1	2	3	4	5
(B41)My classroom is structured in such a way as to promote hands-on exploration and manipulation of concrete materials for science	1	2	3	4	5
(B42)I like to organise group work activities for science	1	2	3	4	5
(B43)It is easy to cater for different learning styles in Natural Science	1	2	3	4	5
(B44)I need a fully-equipped science laboratory to present science experiences for Foundation Phase learners	1	2	3	4	5

54

INDICATE HOW IMPORTANT YOU VIEW NATURAL SCIENCE IN THE FOUNDATION PHASE

(B45)I believe that the main priorities for learning in the Foundation Phase are literacy and numeracy	1	2	3	4	5
(B46)To me, the teaching of science in the Foundation Phase is as important as the teaching of reading	1	2	3	4	5
(B47)I think that the teaching of science skills in the Foundation Phase is as important as the teaching of mathematical skills	1	2	3	4	5
(B48)I think that the teaching of science skills in the Foundation Phase is as important as the teaching of life skills	1	2	3	4	5
(B49)Science education should only have minor emphasis before Grade 4 (Intermediate Phase)	1	2	3	4	5
(B50)I feel satisfied that a solid foundation for Natural Science is provided during Grade R-3 phase	1	2	3	4	5
(B51)I believe that learners in the Foundation Phase are incapable of learning science	1	2	3	4	5
(B52)It is important to develop scientific knowledge and understanding in the Foundation Phase	1	2	3	4	5
(B53)Science must be given a higher priority in the Foundation Phase	1	2	3	4	5
(B54)I think that the time allocated for Natural Science in the Foundation Phase-curriculum is sufficient	1	2	3	4	5

64

INDICATE YOUR UNDERSTANDING OF THE PLACE OF THE NATURAL SCIENCE LEARNING AREA IN THE FOUNDATION PHASE (INTEGRATION)

(B55)In the Foundation Phase, Natural Science should be integrated into the core Learning Areas (Mathematics, Languages, Life Orientation) as an **additional** Learning Outcome	1	2	3	4	5
(B56)I like to integrate science into the Numeracy Learning Programme	1	2	3	4	5
(B57)I like to integrate science into the Literacy Learning Programme	1	2	3	4	5
(B58)I like to integrate science into the Life Skills Learning Programme	1	2	3	4	5
(B59)I believe that Natural Science should **ALWAYS** be taught as part of the Life Skills Learning Programme	1	2	3	4	5

1:Strongly disagree	2:Disagree	3:Neutral/Undecided	4:Agree	5:Strongly agree

(B60)I believe that science is **best taught** in an **integrated** way in the Foundation Phase	1	2	3	4	5
(B61)It is easy to integrate Natural Science **naturally** into the Learning Programmes	1	2	3	4	5
(B62)It is easy to strike a balance between **integration** and **conceptual progression** in Natural Science	1	2	3	4	5
(B63)I think science should be taught as a separate subject	1	2	3	4	5
(B64)I believe that **competence** in Natural Sciences can be attained through the presentation of science in an *integrated way*	1	2	3	4	5

74

TEACHER UNDERSTANDING OF THE NATURAL SCIENCE LEARNING AREA AND THE MEANING of LEARNING OUTCOME/S

(B65)In the Foundation Phase, only LO1 of the Natural Science Learning Area is taught and assessed	1	2	3	4	5
(B66)The LO for Natural Science in the Foundation Phase focuses on ***scientific investigation***	1	2	3	4	5
(B67)I believe that the *weighting* of the Natural Science Learning Outcome in the Foundation Phase is sufficient to provide a solid foundation for science education	1	2	3	4	5
(B68)There is inadequate time for teaching LO1 of Natural Science in the Foundation Phase	1	2	3	4	5
(B69)I think that competence in LO1 of Natural Sciences is sufficient to promote **scientific literacy** in Foundation Phase learners	1	2	3	4	5
(B70)I feel that competence in the LO1 for the Natural Science Learning Area is sufficient to provide a **solid science foundation** to build on in the Intermediate Phase	1	2	3	4	5
(B71)I believe that the **scientific investigative process** is central to the Natural Science Learning Area for the Foundation Phase	1	2	3	4	5
(B72)I am aware that the scientific investigative process includes *planning, doing and reviewing*	1	2	3	4	5
(B73)I provide science experiences for Foundation Phase learners that cover the **complete** *scientific investigative process*	1	2	3	4	5
(B74)There are three or more Learning Outcomes in Natural Science that must be addressed in the Foundation Phase	1	2	3	4	5
(B75)*Competence* in LO1 enable learners to **solve problems**	1	2	3	4	5

85

UNDERSTANDING OF THE PROCESS SKILLS

(B76)I am aware of the process skills as set out in the Natural Science Learning Area Statement	1	2	3	4	5
(B77)I believe that, for Foundation Phase learners, the **process of investigation** in science is as important as the **content** of science	1	2	3	4	5
(B78)I intentionally seek ways to involve the process skills during Natural Science activities	1	2	3	4	5
(B79)I provide opportunities for Foundation Phase learners to use the science process skills in a variety of settings	1	2	3	4	5
(B80)I believe that Foundation Phase learners are too young to use investigative process skills	1	2	3	4	5
(B81)I believe that the process of investigation in the classroom is the same as the one conducted in the science laboratory	1	2	3	4	5
(B82)I understand what each of the process skills involve	1	2	3	4	5
(B83)I often use the **process skills** *plan, do* and *review*	1	2	3	4	5
(B84)*Investigate, reflect,* and *analyse* are process skills as set out in the NSLA	1	2	3	4	5

94

1:Strongly disagree	2:Disagree	3:Neutral/Undecided	4:Agree	5:Strongly agree

SELECTION OF SUITABLE CONTENT

(B85)When I plan science learning experiences, I prefer to use content and concepts from the content area *Life and Living* as described in the Natural Science Learning Area	1	2	3	4	5
(B86)I feel comfortable to provide learning experiences and activities from the strand *Energy and Change*	1	2	3	4	5
(B87)I like presenting activities from the strand *Matter and Materials*	1	2	3	4	5
(B88)Content from *Planet Earth and Beyond* is inappropriate for Foundation Phase learners	1	2	3	4	5
(B89)I make provision for science education in the Foundation Phase through science topics or themes	1	2	3	4	5
(B90)It is difficult to find resources for science	1	2	3	4	5
(B91)It is easy to find appropriate science content from **local contexts**	1	2	3	4	5
(B92)I use mainly books as resources for science	1	2	3	4	5
(B93)I know how to select developmentally appropriate science content for Foundation Phase learners	1	2	3	4	5
(B94)I find at least 30% science content from the local context	1	2	3	4	5

104

PRE-SERVICE TRAINING

(B95)During pre-service (tertiary) training, Natural Science was one of my modules/subjects	1	2	3	4	5
(B96)In pre-service (tertiary) training, I learned the basics of science (Biological, Life, Earth and Space Science)	1	2	3	4	5
(B97)In pre-service (tertiary) training, we explored different methods to teaching science	1	2	3	4	5
(B98)I have had authentic science experiences during pre-service training	1	2	3	4	5
(B99)I have learnt the basics of science during my own school years	1	2	3	4	5
(B100)I acquire the science knowledge I need to teach science through self-study	1	2	3	4	5

110

IN-SERVICE TRAINING

(B101)I received training on how to implement the Revised National Curriculum Statement (RNCS)	1	2	3	4	5
(B102)I feel satisfied about the training I received on how to implement the RNCS	1	2	3	4	5
(B103)I feel that the training I received equipped me adequately to integrate the Natural Science Learning Area specifically	1	2	3	4	5
(B104)In the RNCS training, I learned about the process skills	1	2	3	4	5
(B105)In the RNCS training, I learned how to use the process skills	1	2	3	4	5
(B106)I received in-service training on how to interpret the Natural Science Learning Area for the Foundation Phase	1	2	3	4	5
(B107)I understand what the Natural Science Learning Area for the Foundation Phase entails	1	2	3	4	5
(B108)I am familiar with the content of the Natural Science Learning Area that applies to the Foundation Phase	1	2	3	4	5
(B109)In my school, we receive sufficient guidelines on how to integrate Natural Science effectively	1	2	3	4	5
(B110)I feel that I receive sufficient support from the provincial department on the implementation of the Natural Science Learning Area	1	2	3	4	5
(B111)I feel that I need more training on the Natural Science Learning Area	1	2	3	4	5

1:Strongly disagree	2:Disagree	3:Neutral/Undecided	4:Agree	5:Strongly agree

(B112)I would like to have more science curriculum resources	1	2	3	4	5
(B113)I received sufficient training to design learning programmes, work schedules and learning units	1	2	3	4	5
(B114)When I design learning programmes, work schedules and learning units, I intentionally seek opportunities to integrate Natural Science	1	2	3	4	5

124

(B115) FREQUENCY OF INTEGRATION. Indicate how often you integrate Natural Science in one of the Learning Programmes by writing the most appropriate number in the square provided.

I integrate LO1 of Natural Science at least **once a week** in one of the Learning Programmes	=1	
I integrate LO1 of Natural Science at least **once a month** in one of the Learning Programmes	=2	
I integrate LO1 of Natural Science at least **once a term** in one of the Learning Programmes	=3	
I **rarely** integrate the Learning Outcome/s for Natural Science	=4	

125

INHIBITORS OF SCIENCE TEACHING. Indicate the most important factors that inhibit your teaching of science (if any).Mark the appropriate response (YES/NO) with a ✗.

(B116) Large classes	YES	NO
(B117) Poor resourcing	YES	NO
(B118) Overcrowded curricula	YES	NO
(B119) Inadequate teaching time for Natural Science	YES	NO
(B120) Lack of knowledge and skills to teach science	YES	NO
(121) Inadequate curriculum resources	YES	NO
(122) Inadequate **Learning Outcomes** for Natural Science in the Foundation Phase	YES	NO
(123) Other (If YES, specify)	YES	NO

133

SECTION C: Open-ended questions

Please reflect on the situation in your classroom and/or school. Your honest response will be appreciated.

(C1) ALLOCATION OF FORMAL TEACHING TIME PER WEEK. Please indicate the time you allocate to Natural Science in each of the Learning Programmes by writing the time in the block provided.

I allocate ---- teaching time (in hours and minutes) to Natural Science in the Literacy Learning Programme **per week**	
I allocate ---- teaching time (in hours and minutes) to Natural Science in the Numeracy Learning Programme **per week**	
I allocate ---- teaching time (in hours and minutes) to Natural Science in the Life Skill Learning Programme **per week**	
Other (Specify)	

(C2) USE OF PROCESS SKILLS. Please indicate the science process skills that are most frequently used in the science activities that you present in your class.

....

....

(C3) In what way, do you think, can science teaching in your school be improved?

....

....

Thank you for your cooperation!

APPENDIX C: AFRIKAANS

NAVORSINGSVRAELYS.

Beste Onderwyser, hierdie navorsing het ten doel om jou persepsie oor die waarde, plek en metode van onderrig van Natuurwetenskappe in die Grondslagfase te bepaal. As onderwyser in die praktyk, is jou bydrae belangrik vir die sukses daarvan. Gevolglik sal jou eerlike respons waardeer word. Moet asseblief nie jou naam op die vraelys skryf nie. Daar sal slegs kollektief verslag gedoen word oor die resultate verkry.

VRAELYSNOMMER			

3

AFDELING A: Biografiese en Demografiese gegewens.

Beantwoord asseblief die vrae deur die toepaslike syfer in die gegewe blokkie in te vul.

(A1) Jou ouderdom

30 jaar en jonger = 1	Ouer as 31 = 2	

4

(A2) Hoogste Akademiese/Professionele Kwalifikasie

Onderwysdiploma (3jaar)	= 1	Baccalaureus Graad	= 3	
Hoër/Verdere Onderwysdiploma	= 2	Baccalaureus Educationis	= 4	
Ander	= 5 (Spesifiseer ....)			

5

(A3) Jare ondervinding as Grondslagfase-onderwyser

Minder as 8 jaar = 1	9 jaar en meer = 2	

6

(A4) Die graad wat jy tans onderrig

Graad R = 1	Graad 1 = 2	Graad 2 = 3	Graad 3 = 4	

7

(A5) Tipe skool waar jy werk

Staatskool = 1	Privaatskool = 2	
Ander = 3 (Spesifiseer ....)		

8

(A6) Medium van onderrig

Afrikaans = 1	Engels = 2	
Ander = 3 (Spesifiseer ....)		

9

(A7) Jou provinsie

Gauteng	= 1	Noordwes	= 4	Weskaap	= 7	
KwaZulu-Natal	= 2	Limpopo	= 5	Ooskaap	= 8	
Mpumalanga	= 3	Vrystaat	= 6	Noordkaap	= 9	

10

AFDELING B

In die volgende deel van die vraelys moet jy jou graad van instemming met die stellings aandui deur die gepaste blokkie met 'n kruisie (✘) te merk.

Gebruik die volgende skaal:

1:Stem glad nie saam nie	**2:Stem nie saam nie**	**3:Neutraal/Besluiteloos**	**4:Stem saam**	**5:Stem beslis saam**	**6:Nvt**

OM JOU PERSOONLIKE ERVARINGE TE HERROEP ten opsigte van wetenskap, dui asseblief aan in watter mate jy met die volgende stellings saamstem of nie.

(B1)Ek kan spesifieke positiewe ervaringe in die wetenskapklas tydens Hoërskool onthou	1	2	3	4	5	6
(B2)Biologie was een van my gunstelingvakke in die Hoërskool	1	2	3	4	5	6

12

(B3)Ek het pret gehad met wetenskap op Laerskool	1	2	3	4	5
(B4)Ek hou van wetenskap	1	2	3	4	5
(B5)Ek voel oor die algemeen positief oor wetenskap	1	2	3	4	5
(B6)Ek vind wetenskap moeilik	1	2	3	4	5
(B7)Ek beskou myself as 'n wetenskaplik-geletterde persoon	1	2	3	4	5
(B8)Wetenskap help ons om ons daaglikse probleme te hanteer	1	2	3	4	5
(B9)Ek voel gemakliker met Biologiese wetenskappe (plante, diere, ens)	1	2	3	4	5
(B10)Ek verkies Fisiese wetenskappe (masjiene, elektrisiteit, ens)	1	2	3	4	5
(B11)Aarde- en Ruimtewetenskappe is my gunsteling wetenskaponderwerpe	1	2	3	4	5
(B12)Op skool is meisies minder aangemoedig in die wetenskapklas as seuns	1	2	3	4	5

22

DUI AAN HOE JY VOEL OOR DIE AANBIEDING VAN WETENSKAP

(B13)Ek vind dit moeilik om wetenskap aan te bied	1	2	3	4	5
(B14)Ek hou daarvan om wetenskapverwante onderwerpe/temas/aktiwiteite in my klas aan te bied	1	2	3	4	5
(B15)Ek is 'n goeie wetenskaponderwyser	1	2	3	4	5
(B16) Ek voel gemaklik om Grondslagfase-leerders se vrae oor wetenskap te beantwoord	1	2	3	4	5
(B17)Ek het vertroue in my vermoëns om wetenskap aan Grondslagfase-leerders te onderrig	1	2	3	4	5
(B18)Ek beskik nie oor die kennis en vaardighede om wetenskap effektief te onderrig nie	1	2	3	4	5
(B19)Ek glo dat wetenskap deur 'n spesialis onderwyser onderrig behoort te word	1	2	3	4	5

29

DUI JOU SIENING VAN DIE AARD VAN WETENSKAP AAN

(B20)Ek glo dat wetenskap uit feite, konsepte en teorieë bestaan wat in die klas onderrig moet word	1	2	3	4	5
(B21)Wetenskap in die Grondslagfaseklas is gelykstaande aan eksperimente-doen	1	2	3	4	5
(B22)Ek voel dat Grondslagfase-leerders 'n verskeidenheid belangrike waardes en ingesteldhede deur wetenskap kan aanleer	1	2	3	4	5
(B23)Ek glo dat wetenskap deel is van ons alledaagse lewe	1	2	3	4	5

33

DUI JOU SIENING AAN VAN DIE VERMOËNS VAN GRONDSLAGFASE-LEERDERS OM WETENSKAP TE LEER

(B24)Ek glo dat alle Grondslagfase-leerders van nature wetenskaplikes is	1	2	3	4	5
(B25)Ek dink dat alle Graad R tot Graad 3-leerders wetenskap kan leer	1	2	3	4	5
(B26)Ek glo dat wetenskap te moeilik is vir sommige Grondslagfase-leerders	1	2	3	4	5
(B27)Kinders kan gelukkige, nuttige lewens lei sonder om wetenskaplik geletterd te wees	1	2	3	4	5

37

METODE VAN NATUURWETENSKAP-AANBIEDING

(B28)Ek weet hoe leerders wetenskap die beste aanleer	1	2	3	4	5
(B29)Ek bied geleenthede vir leerders om praktiese werk te doen in wetenskap	1	2	3	4	5
(B30)EK verskaf geleenthede vir leerders om hul eie kennis en begrip van wetenskap te ontwikkel	1	2	3	4	5
(B31)Ek dink dat wetenskapkennis die beste opgedoen word deur papegaai-leer (memorisering)	1	2	3	4	5

1: Stem glad nie saam nie	2: Stem nie saam nie	3: Neutraal/Besltuiteloos	4: Stem saam	5: Stem beslis saam

(B32)Ek is bewus van die mees gepaste onderrigmetode vir Natuurwetenskappe in die Grondslagfase	1	2	3	4	5
(B33)Ek probeer om elke leerder se voorkennis te bepaal voor ek nuwe wetenskapinhoud onderrig	1	2	3	4	5
(B34)Ek gebruik hoofsaaklik werkkaarte om leerders se prestasies in wetenskap te assesseeer	1	2	3	4	5
(B35)Ek bied geleenthede vir leerders om wetenskap te leer deur praktiese *(hands-on)* toepassing van wetenskap	1	2	3	4	5
(B36)Ek is vaardig in die aanmoediging van kritiese denke en probleemoplossing in wetenskap	1	2	3	4	5
(B37)Ek voorsien ruim geleentheid vir leerders om met konkrete voorwerpe te werk in wetenskap	1	2	3	4	5
(B38)Ek voorsien ruim geleentheid vir leerders om hulle wetenskapervaringe mondelings met mekaar in die klas te deel	1	2	3	4	5
(B39)Ek dra hoofsaaklik wetenskapkennis oor deur leerders van wetenskap te vertel	1	2	3	4	5
(B40)Ek dink groepwerk is essensieel vir die effektiewe aanleer van wetenskap	1	2	3	4	5
(B41)My klaskamer is so ingerig dat toepassing-gerigte (*hands-on*) ondersoek en manipulering van konkrete voorwerpe in wetenskap aangemoedig word	1	2	3	4	5
(B42)Ek organiseer graag groepwerkaktiwiteite vir wetenskap	1	2	3	4	5
(B43)Dit is maklik om voorsiening te maak vir verskillende leerstyle in Natuurwetenskap	1	2	3	4	5
(B44)Ek het 'n ten volle toegeruste wetenskaplaboratorium nodig om wetenskapervaringe vir Grondslagfase-leerders aan te bied	1	2	3	4	5

54

DUI AAN HOE BELANGRIK JY NATUURWETENSKAP IN DIE GRONDSLAGFASE BESKOU

(B45)Ek glo die hoofprioriteite vir leer in die Grondslagfase is geletterdheid en gesyferdheid	1	2	3	4	5
(B46)Vir my is wetenskaponderrig in die Grondslagfase net so belangrik as leesonderrig	1	2	3	4	5
(B47)Ek dink dat die onderrig van wetenskapvaardighede in die Grondslagfase ewe belangrik is as die onderrig van wiskundevaardighede	1	2	3	4	5
(B48)Ek dink dat die onderrig van wetenskapvaardighede in die Grondslagfase ewe belangrik is as die onderrig van lewensvaardighede	1	2	3	4	5
(B49)Wetenskaponderrig behoort slegs minimale klem te dra voor Graad 4 (Intermediêre Fase)	1	2	3	4	5
(B50)Ek voel tevrede dat 'n stewige grondslag vir Natuurwetenskap gevestig word tydens die Graad R-3-fase	1	2	3	4	5
(B51)Ek glo dat leerders in die Grondslagfase nie in staat is om wetenskap aan te leer nie	1	2	3	4	5
(B52)Dit is belangrik om wetenskaplike kennis en begrip in die Grondslagfase te ontwikkel	1	2	3	4	5
(B53)Wetenskap behoort hoër prioriteit in die Grondslagfase te kry	1	2	3	4	5
(B54)Ek dink die tyd wat vir wetenskap in die Grondslagfase-kurrikulum toegeken word is genoegsaam	1	2	3	4	5

64

DIE PLEK VAN DIE NATUURWETENSKAPPE-LEERAREA IN DIE GRONDSLAGFASE (INTEGRASIE)

(B55)Natuurwetenskap in die Grondslagfase behoort geïntegreer te word met die kern-leerareas (Wiskunde, Tale, Lewensorientering) as 'n **addisionele** Leeruitkoms	1	2	3	4	5
(B56)Ek integreer graag wetenskap in die Gesyferdheidsleerprogram	1	2	3	4	5
(B57)Ek integreer graag wetenskap in die Geletterdheidsleerprogram	1	2	3	4	5
(B58) Ek integreer graag wetenskap in die Lewensvaardighedeleerprogram	1	2	3	4	5

1: Stem glad nie saam nie	2: Stem nie saam nie	3: Neutraal/Besltuiteloos	4: Stem saam	5: Stem beslis saam

(B59)Ek glo dat wetenskap **ALTYD** as deel van die Lewensvaardighedeleerprogram onderrig behoort te word	1	2	3	4	5
(B60)Ek glo dat wetenskap die **beste** op 'n **geïntegreerde** wyse onderrig word in die Grondslagfase	1	2	3	4	5
(B61)Dit is eenvoudig om Natuurwetenskap **op 'n natuurlike wyse** in die Leerprogramme te integreer	1	2	3	4	5
(B62)Dit is maklik om 'n balans te tref tussen **integrasie** en **konseptuele progressie** in Natuurwetenskappe	1	2	3	4	5
(B63)Ek dink wetenskap behoort as 'n aparte vak onderrig te word	1	2	3	4	5
(B64)Ek glo dat **kundigheid** in Natuurwetenskap verkry kan word deur wetenskap op 'n *geïntegreerde wyse* aan te bied	1	2	3	4	5

74

DUI ASB JOU SIENING VAN DIE NATUURWETENSKAPPE-LEERAREA EN DIE BETEKENIS VAN LEERUITKOMSTE AAN

(B65)Slegs LU1 van die Natuurwetenskappe-leerarea word in die Grondslagfase onderrig en geassesseer	1	2	3	4	5
(B66)Die LU vir Natuurwetenskappe in die Grondslagfase fokus op ***wetenskaplike ondersoek***	1	2	3	4	5
(B67)Ek meen die *waarde/gewig* van die Natuurwetenskappe-leeruitkoms in die Grondslagfase is voldoende om 'n stewige grondslag vir wetenskap-onderrig te verskaf	1	2	3	4	5
(B68)Daar is onvoldoende tyd om LU1 van Natuurwetenskap in die Grondslagfase te onderrig	1	2	3	4	5
(B69)Ek dink dat kundigheid in LU1 van Natuurwetenskappe voldoende is om **wetenskaplike geletterdheid** by Gronslagfase-leerders te bevorder	1	2	3	4	5
(B70)Ek voel dat bevoegdheid in LU1 van die Natuurwetenskappe-leerarea voldoende is om 'n **stewige grondslag** daar te stel waarop voortgebou kan word in die Intermediêre Fase	1	2	3	4	5
(B71)Ek glo dat die **wetenskaplike ondersoekproses** sentraal staan in die Natuurwetenskappe-leerarea vir die Grondslagfase	1	2	3	4	5
(B72)Ek is bewus daarvan dat *beplan, doen en hersien* by die wetenskaplike ondersoekproses ingesluit word	1	2	3	4	5
(B73)Ek bied wetenskapervarings aan Grondslagfase-leerders wat die *wetenskaplike ondersoek-proses* **volledig** dek	1	2	3	4	5
(B74)Daar is drie of meer leeruitkomste vir Natuurwetenskappe wat in die Grondslagfase aandag moet kry	1	2	3	4	5
(B75)*Kundigheid* in LU1 stel die leerder in staat om **probleme op te los**	1	2	3	4	5

85

SIENING VAN DIE PROSESVAARDIGHEDE

(B76)Ek is bewus van die prosesvaardighede soos in die Natuurwetenskappe-leerareaverklaring uiteengesit	1	2	3	4	5
(B77)Ek glo dat die **ondersoekproses** in wetenskap ewe belangrik is as die **inhoud** vir Grondslagfase-leerders	1	2	3	4	5
(B78)Ek soek doelbewus na maniere om die prosesvaardighede by Natuurwetenskapaktiwiteite in te skakel	1	2	3	4	5
(B79)Ek bied geleenthede waar Grondslagfase-leerders die wetenskapprosesvaardighede in 'n verskeidenheid van situasies kan gebruik	1	2	3	4	5
(B80)Ek meen Grondslagfase-leerders is nog te jonk om ondersoekende prosesvaardighede te gebruik	1	2	3	4	5
(B81)Ek glo die ondersoekproses in die klaskamer is dieselfde as dié in die wetenskap-laboratorium	1	2	3	4	5
(B82)Ek verstaan wat elk van die prosesvaardighede behels	1	2	3	4	5
(B83)Ek gebruik dikwels die **prosesvaardighede** *beplan, doen* en *hersien*	1	2	3	4	5
(B84)*Ondersoek, nadink* en *analiseer* is prosesvaardighede	1	2	3	4	5

94

KEUSE VAN TOEPASLIKE INHOUD

1: Stem glad nie saam nie	2: Stem nie saam nie	3: Neutraal/Besltuiteloos	4: Stem saam	5: Stem beslis saam

(B85)Wanneer ek wetenskap-leerervaringe beplan, verkies ek om inhoud en konsepte uit die inhoudsveld *Die lewe en Lewende Dinge* soos in die Natuurwetenskappe-leerarea beskryf, te gebruik	1	2	3	4	5
(B86)Ek voel gemaklik daarmee om leerervaringe en aktiwiteite uit die inhoudsveld *Energie en Verandering* aan te bied	1	2	3	4	5
(B87)Ek hou daarvan om aktiwiteite uit die inhoudsveld *Materie en Materiaal/Stowwe* aan te bied	1	2	3	4	5
(B88)Inhoud uit *Die Aarde en die Ruimte* is onvanpas vir Grondslagfase-leerders	1	2	3	4	5
(B89)Ek maak voorsiening vir wetenskaponderrig deur middel van wetenskaponderwerpe en -temas	1	2	3	4	5
(B90)Dit is moeilik om bronne te vind vir wetenskap	1	2	3	4	5
(B91)Dit is maklik om gepaste wetenskapinhoud te kry uit **plaaslike kontekste**	1	2	3	4	5
(B92)Ek gebruik hoofsaaklik boeke as bronne vir wetenskap	1	2	3	4	5
(B93)Ek weet hoe om ontwikkelingstoepaslike wetenskapinhoud vir Grondslagfaseleerders te kies	1	2	3	4	5
(B94)Ek kry ten minste 30% wetenskapinhoud uit die plaaslike gemeenskap	1	2	3	4	5

104

VOORGRAADSE OPLEIDING

(B95)Tydens my tersiêre opleiding was Natuurwetenskappe een van my vakke/modules	1	2	3	4	5
(B96)Tydens my tersiêre opleiding het ek basiese kennis aangaande wetenskap (Biologiese, Fisiese, Aarde en Ruimtewetenskappe) opgedoen	1	2	3	4	5
(B97)Tydens my tersiêre opleiding het ons verskillende wetenskaponderrigmetodes behandel	1	2	3	4	5
(B98)Tydens my tersiêre opleiding is ek blootgestel aan egte wetenskapervaringe	1	2	3	4	5
(B99)Ek het my basiese wetenskapkennins gedurende my eie skooljare opgedoen	1	2	3	4	5
(B100)Ek verkry die wetenskapkennis wat ek nodig het om wetenskap te onderrig deur selfstudie	1	2	3	4	5

110

INDIENSOPLEIDING

(B101)Ek het opleiding gekry om die Hersiene Nasionale Kurrikulumverklaring (HNKV) te implimenteer	1	2	3	4	5
(B102)Ek voel tevrede met die opleiding wat ek gekry het om die HNKV te implimenteer	1	2	3	4	5
(B103)Ek voel dat die onderrig wat ek ontvang het my genoegsaam toegerus het om die Natuurwetenskappe-leerarea spesifiek effektief te integreer	1	2	3	4	5
(B104)Tydens die HNKV-opleiding het ek van die prosesvaardighede geleer	1	2	3	4	5
(B105)Tydens die HNKV-opleiding het ek geleer hoe om die prosesvaardighede te gebruik	1	2	3	4	5
(B106)Ek het indiensopleiding ontvang oor hoe om die Natuurwetenskappe-leerarea vir die Grondslagfase te interpreteer	1	2	3	4	5
(B107)Ek verstaan wat die Natuurwetenskappe-leerarea vir die Grondslagfase behels	1	2	3	4	5
(B108)Ek is vertroud met die inhoud van die Natuurwetenskappe-leerarea wat van toepassing is op die Grandslagfase	1	2	3	4	5
(B109)In my skool ontvang ons genoeg riglyne om die Natuurwetenskappe effektief te integreer	1	2	3	4	5
(B110)Ek voel dat ek genoegsame ondersteuning ontvang van die **provinsiale departement** oor die implimentering van die Natuurwetenskappe-leerarea	1	2	3	4	5
(B111)Ek voel dat ek meer opleiding nodig het in die Natuurwetenskappe-leerarea	1	2	3	4	5

1: Stem glad nie saam nie	2: Stem nie saam nie	3: Neutraal/Besltuiteloos	4: Stem saam	5: Stem beslis saam

(B112)Ek sou graag meer Natuurwetenskap-**kurrikulumbronne** wou hê	1	2	3	4	5
(B113)Ek het genoegsame opleiding gehad om leerprogramme, werkskedules en leereenhede te ontwerp	1	2	3	4	5
(B114)Wanneer ek leerprogramme, werkskedules en leereenhede ontwerp, soek ek doelbewus geleenthede om Natuurwetenskappe te integreer	1	2	3	4	5

124

(B115) FREKWENSIE VAN INTEGRASIE. Dui aan hoe gereeld jy Natuurwetenskappe in een van die Leerprogramme integreer deur die mees gepaste syfer in die gegewe blokkie in te vul.

Ek integreer LU1 van Natuurwetenskappe ten minste **een maal per week** in een van die Leerprogramme =1 Ek integreer LU1 van Natuurwetenskappe ten minste **een maal per maand** in een van die Leerprogramme =2 Ek integreer LU1 van Natuurwetenskappe ten minste **een maal per termyn** in een van die Leerprogramme =3 Ek integreer LU1 van Natuurwetenskappe **selde** =4	

125

INHIBEERDERS VAN WETENSKAPONDERRIG. Dui die belangrikste faktore aan wou jou daarvan weerhou om wetenskap te onderrig (indien enige). Merk die gepaste respons (JA/NEE) met 'n ***X***.

(B116) Groot klasse	JA	NEE
(B117) Onvoldoende toerusting	JA	NEE
(B118) Oorvol kurrikulum	JA	NEE
(B119) Onvoldoende/te min onderrigtyd vir Natuurwetenskappe	JA	NEE
(B120) Gebrek aan kennis en vaardighede om wetenskap te onderrig	JA	NEE
(B121) Onvoldoende kurrikulumbronne	JA	NEE
(B122) Onvoldoende/te min **leeruitkomste** vir Natuurwetenskappe in die Grondslagfase	JA	NEE
(B123) Ander (Indien JA, spesifiseer)	JA	NEE

133

AFDELING: Oop vrae

Reflekteer asseblief op die situasie in jou klaskamer en/of skool. Jou opregte opinie sal waardeer word.

(C1) TOEKENNING VAN FORMELE ONDERRIGTYD PER WEEK. Dui asseblief aan hoeveel tyd jy vir Natuurwetenskappe in elk van die Leerprogramme toeken deur die tyd in die gegewe blokkie in te vul.

Ek ken ---- onderrigtyd **per week** toe (in ure en minute) vir Natuurwetenskappe in die Geletterdheidsleerprogram	
Ek ken ---- onderrigtyd **per week** toe (in ure en minute) vir Natuurwetenskappe in die Gesyferdheidsleerprogram	
Ek ken ---- onderrigtyd **per week** toe (in ure en minute) vir Natuurwetenskappe in die Lewensvaardighede-leerprogram	
Ander (Spesifiseer)	

(C2) GEBRUIK VAN PROSESVAARDIGHEDE. Dui asseblief die wetenskapprosesvaardighede aan wat jy die meeste gebruik in die wetenskapaktiwitieite wat jy in jou klas aanbied.

....

....

(C3) Op watter manier dink jy kan Natuurwetenskaponderrig in jou skool verbeter word?

....

....

Baie dankie vir jou samewerking!

APPENDIX D

"Views of a scientist": BEd iii students in *Learning Area Natural Science*, University of Pretoria (2006). "The mythical scientists are that strange breed of 'men', intelligent, grey-haired, bespectacled, eccentric, with test tubes or leaky pens in their pockets and a bemused expression on their faces, who muck up the environment." (Johnston 1996:107).