A case study of the implementation of science process skills for Grades 4 to 7 learners in Natural Sciences in a South African Primary School

By

J. N. AMBROSS

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PROMOTERS: Dr S Blignaut
Mr L Meiring

DECLARATION

I, Johannes, Nikolaas Ambross, hereby declare that ***"A case study of the implementation of science process skills for grades 4-7 learners in Natural Sciences in a South African Primary School"*** is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another university or for another qualification.

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ABSTRACT

With the publication of the National Curriculum Statement (2002) (NCS) the use and development of science process skills have become a critical part of the teaching and learning of the Natural Sciences in South Africa. This study sought to evaluate the implementation and development of these basic skills by four grade 4-7 educators at classroom level at a primary school in the northern areas of Port Elizabeth. Qualitative data for this evaluation were collected through educator interviews, classroom observation as well as a focus-group interview. Quantitative data were gathered by means of a Science Process Skills Observation Scale and through examining the learners' assessment activities. An Assessment Activity Science Process Skill Rating-Scale was used to evaluate assessment activities.

Data generated from this study were carefully analysed and on the basis of their interpretation it was concluded that the implementation and development of science process skills were strongly influenced by the educators' understanding of these basic concepts, the belief held by each educator about their role and how their learners learn, the presence of quality support and effective training programmes as well continuous professional development.

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CHAPTER ONE

INTRODUCTION AND OVERVIEW

1. INTRODUCTION

With the introduction of the National Curriculum Statement (NCS, 2002) in South Africa the use and development of science process skills have become an essential part of the teaching and learning of Natural Sciences. These skills, according to Harlen (2000), are one of the ingredients that constitute scientific literacy, that is an understanding of how science works and how new knowledge is generated, which is one of the goals of the NCS. These skills, which will be further elaborated on later in this study, can be developed through inquiry-based learning. It should be noted that in the context of this study inquiry-based learning implies the learners engaging in observing and comparing phenomena, asking questions to be investigated, making predictions, conducting investigations and collecting data, recording results and lastly evaluating and communicating their findings (NCS, 2002). This approach, namely inquiry-based learning as suggested by the NCS, has shifted the focus of science education from the traditional memorising of facts, concepts and teacher-centred teaching towards the facilitation of more innovative approaches that are learner-centred, cooperative and where the process is more important than the product.

Many studies conducted with middle and high school students found that inquiry-based science activities had positive effects on students' achievement, cognitive development, laboratory skills, science process skills and an understanding of science knowledge as a whole when compared to students taught using a traditional approach (Gibson & Chase, 2002).

Developing these skills does not happen of its own accord: learners have to acquire them (Van Huyssteen, 1981). Developing these skills and being able to use them come with practice (Harlen, 2000).

2. STATEMENT OF THE RESEARCH PROBLEM

Despite the call from the Department of Education (NCS, 2002) to make inquiry-based learning more prevalent in primary science education in South Africa, as an experienced science practitioner, and in conversation with the science educators at the school where the study was conducted, the researcher observed that there was little evidence that science teaching centred on inquiry. The discussions between the educators in the Natural Sciences Learning Area meetings also revealed that most science educators acted as transmitters of knowledge in which they predominantly focus on the teaching of content. This observation was supported by our Natural Sciences facilitator who visited the school recently to examine the educators' portfolios, their assessment practices as well as the teaching and learning activities each educator used to ensure that appropriate standards are maintained. He voiced his concern about the overemphasis of content at the expense of skills by these educators.

Against this background the purpose of this study is to evaluate the implementation and development of science process skills in the teaching and learning of Natural Sciences for grades 4 - 7 learners at classroom level at Mzanzi[1] Primary, a school located in Port Elizabeth. It is an attempt to specify curriculum practices implied by the innovation with regard to the topic under discussion through the clarification of concepts, highlighting existing problems that should be addressed by the Natural Sciences facilitators and evaluating the extent to

[1] This is not the real name of the school.

which these educators accept and carry out their roles. This study will also make recommendations under which the implementation and development of these process skills are to succeed. In the light of the above, this study will be guided and structured around the following research questions:

3. THE RESEARCH QUESTION

The primary question in this study is:

How has the implementing of science process skills impacted on the Natural Sciences educator?

The following subordinate questions are asked:

- *How is the concept science process skills understood by grades 4 to 7 educators?*
- *To what extent are these skills currently being implemented by the grades 4 to 7 educators?*
- *What are the perceived impediments to implementation?*
- *What support do educators need to improve their classroom practices with regard to the teaching of the basic science process skills?*

4. RATIONALE

One of the central goals of science education in South Africa is to help learners to learn science content through methods of inquiry by means of which they are requested to use a variety of science process skills to explore their natural world, question it and make sense of it through the formation of concepts (NCS, 2002). Despite the central role of teaching science through inquiry, the researcher observed that at the school where the study was conducted,

rote learning and memorisation remained a common practice in most of their science classes. This may possibly be attributed to the fact that many educators were not exposed to inquiry-based learning during their initial training programmes. Gibson and Chase (2002) maintain that inquiry-based learning is a more effective way for students to learn science since this approach improves the learners' attitude towards science whereas negative attitudes result from the traditional method. This study attempts to bring to into focus those factors which are responsible for some educators not implementing science process skills in their classroom practices.

5. CLARIFICATION OF CONCEPTS

In designing a research project it is essential to explain the terms used as well as the assumptions on which the study is based in order to make the implications clearer.

5.1 Evaluation

Stufflebeam and Shinkfield (2007) define an evaluation as a systematic investigation of some object's value. Operationally, they state that evaluation is the process of delineating, obtaining, reporting and applying descriptive and judgmental information about some object's merit, worth, significance and probity in order to guide decision-making, support accountability, disseminate effective practices and increase understanding of the involved phenomena. To ensure an evaluation's utility, feasibility, propriety and accuracy, Stufflebeam and Shinkfield (2007) designed a model called the CIPP model for evaluation purposes. The CIPP model's core concepts are denoted by the acronym CIPP, which stands for evaluations of an entity's context, input, process and product. Context evaluation is undertaken to assess the needs, problems, assets, and opportunities to help decision-makers to

define goals and priorities and to help the relevant users to judge goals, priorities and outcomes. According to Stufflebeam and Shinkfield (2007), an input evaluation assesses alternative approaches, competing action plans, staffing plans and budgets for feasibility and potential cost effectiveness to meet targeted needs and to achieve goals. A process evaluation is an ongoing check on a programme's implementation and documentation of the process. It seeks to identify anticipated consequences of the programme in time for programme managers to avoid those that are undesirable, and to provide ongoing information on the performance of the programme (Windham & Chapman, 1990). Product evaluation is undertaken to measure, interpret and judge an enterprise's achievements. One of its purposes is to decide whether a given programme, project, service or other enterprise is worth continuing, repeating or extending to other settings (Stufflebeam & Shinkfield, 2007).

The evaluation undertaken in this study is based on the assumptions of process evaluation according to Windham and Chapman (1990). This study may also be used for formative purposes which are synonymous with product evaluation based on Herman, Morris and Fitz-Gibson, (as in cited in Brainard, 1996) who view formative evaluation as a focus on providing information to planners and implementers on how to improve and refine a developing or ongoing programme.

5.2 Implementation

A major contributor to endeavours such as the implementation of new educational programmes is the Canadian Michael Fullan (2007). In several books and journal articles he has provided increasingly deeper insight into ways in which districts, educators, communities and principals can bring about desired change. In his recent publication, Fullan (2007)

defined implementation as a process of putting into practice an idea, programme, or set of activities and structures, new to people attempting or expected to change. He asserts that "change is a process, not an event" (Fullan, 2007, p. 68) and he also groups the factors affecting the implementation of a new programme into the following areas: characteristics of change (the need to change, clarity and complexity about change as well as the quality and practicality of the programme), local characteristics (characteristics of the districts, principals and educators) and lastly, external factors (the government, parents, technology and businesses). However, this study focuses on one of the local factors, namely the educator since the implementation of any reform depends on educators as the implementation of a reform-based curriculum usually requires a transformation in teachers' ideas about the subject matter, teaching and the learning of science (Powell & Anderson, 2002). It is the interaction of a teacher's knowledge and beliefs about the nature of the reform that determines what actually happens in the classroom (Roehrig et al., 2007).

This process, however, according to Bishop (1991), is not a matter of simply supplying the appropriate technical information (e.g. a syllabus, textbook or teachers' guide) but rather a matter of changing attitudes, skills, values and relationships. These changes go hand-in-hand with complexity and chaos (Hargreaves, 2000), but successful implementation requires that the process be steered and managed properly.

5.3 Nature of Science (NoS)

Since science education in the country has undergone many changes, one of the core concepts that has been highlighted by the NCS is the changing view of the NoS. There are many definitions of the NoS. However, this study chooses the definition recommended by the

NCS since it describes what aspects of the NoS educators need to teach their learners. The NCS views science as a human activity, dependent on assumptions which change over time as people acquire new information and change their ways of viewing the world. It has been "shaped by the search to understand the world through observation, codifying and testing ideas, and has evolved to become part of the cultural heritage of all nations" (NCS, 2002 p. 4). The NCS also asserts that to be accepted as science, certain methods of inquiry are generally used. They promote reproducibility, attempts at objectivity and a systematic approach to scientific inquiry. This description provided by the NCS correlates well with the views of researchers such as Harlen (2000), one of the major contributors to contemporary thought on the processes of science education, Ward, Roden, Hewlett and Foreman (2008) as well as the National Standards for Science Education (NSSE, 1992), the benchmark of science education in the United States of America.

5.4 Process skills

The term 'process skills' refers to learners' cognitive activity of creating meaning and structure from new information and experiences (NCS, 2002). These skills, according to Ward et al. (2008), are the backbone of the National Science Curriculum and are embedded in scientific inquiry. In order for the learners to give meaning and structure to new information gathered and to undertake an approach to scientific inquiry, the following science process skills have been highlighted by the NCS for Natural Sciences:

5.4.1 Observing and comparing

Observing and comparing may involve the learner in noting similarities and differences in objects, organisms and events with and without prompting by the educator, describing them in general terms, or describing them numerically.

5.4.2 Questioning

This process skill may involve thinking of questions which could be asked about the situation, recognising a question that can be answered by scientific investigation, or re-wording the question to make it scientifically testable.

5.4.3 Predicting

This involves the learners in using knowledge to decide what will happen if something is changed in a situation. The skill includes giving learners the opportunity to respond to 'what if' questions and make predictions from patterns in information.

5.4.4 Conducting investigations and collecting data

Conducting investigations and collecting data promote learner independence as the learner carries out instructions and procedures involving a small number of steps. H/she follows a simple worksheet to set up equipment to obtain information and collect data as the investigation purpose requires.

5.4.5 Recording results

This process skill may involve the learners in recording on a form which is prescribed (sentences, lists, tables, labelled diagrams), 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 educator.

5.4.6 Evaluating and communicating results

This skill is important in helping the learner to reflect on his or her own learning. The learners are given the opportunity to report on the group's procedure and results obtained. Communication also involves more conventional science forms such as tables, concept maps, graphs and constructed models.

6. RESEARCH METHODOLOGY

The research methodology employed for this study employed both quantitative and qualitative research methods. Quantitative research relies heavily on standardised and numerical data as well as statistical analysis while qualitative research predominantly relies on words, images and on searching for themes and patterns in narrative data (Johnson & Christensen, 2004). Although both quantitative and qualitative research methods were used concurrently, qualitative research methods were the central data-gathering method since this study was fairly descriptive in nature and in the search for themes and patterns.

One of the major distinguishing characteristics of qualitative research is the fact that the researcher attempts to understand people in terms of their own definition of their world (Mouton, 2001). The qualitative section of the study was therefore designed to develop a richer understanding of the educators' understanding of science process skills and how this understanding was practised in the science classroom. The quantitative section of the study was designed to find out whether there is a connection between the educators' current practices, beliefs and their implementation of science process skills. By combining both

research methods (quantitative and qualitative) different theories and beliefs emerged from the practices of the educators teaching the science curriculum.

7. OUTLINE OF THE STUDY

This study consists of five chapters. The contents of the chapters are as follows:

Chapter One describes the introduction and provides a theoretical background to the study. The problem is stated, the purpose discussed, certain concepts explained and the research methodology outlined.

Chapter Two reviews the existing scholarship on evaluation, implementation, science process skills the nature of science, inquiry-based learning and scientific literacy.

Chapter Three describes the methodology followed to collect data and the research design.

Chapter Four presents and discusses the results obtained from the interviews, observations, focus-group interviews, learner assessment activity books as well as their implications.

Chapter Five presents the findings, conclusions and the recommendations that may assist the educators to improve their practices regarding this particular topic.

CHAPTER TWO

THEORETICAL FRAMEWORK / LITERATURE REVIEW

1. INTRODUCTION

Chapter Two reviews relevant literature associated with the nature, implementation and evaluation of science process skills in the primary school science classroom. Science process skills can be aligned with inquiry-based learning (Huber & Moore, 2001) and both of these concepts were introduced in the teaching of Natural Sciences with publication of the National Curriculum Statement (NCS) (Department of Education, 2002). It is these concepts that sought to change the emphasis of primary school science from a body of knowledge to be mastered towards something more like the way science is practiced in real life (Monhardt & Monhardt, 2006).

To provide a framework in which the above is discussed, a brief discussion of the nature of science, how knowledge is constructed through cognitive processes and scientific literacy takes place. The chapter continues with short outlines of inquiry based-learning, research into the educators' understanding of science process skills and process skills in the NCS.

This chapter concludes by reviewing hindrances that might prevent the implementation and development of science process skills and briefly highlighting possible recommendations found in the literature that might support educators to improve their practices regarding the teaching of science process skills.

2. IMPLEMENTATION

This study focuses on the implementation of science process skills, one of the dominant ideas introduced by the NCS (DoE, 2002). Implementation or delivery of educational change consists of the process of "putting into practice an idea, programme or set of activities, and structure new to people attempting or expected to change" (Fullan, 2007, p. 84). However, according to Bishop (1991), this process is not simply a matter of supplying technical information (e.g. a syllabus, textbook or teachers' guide), but rather a matter of changing attitudes, skills, values and relationships. These changes are not easy to achieve, but successful implementation requires that the process be steered and managed properly.

The implementation of a new programme or curriculum must ultimately be put into practice at micro level, that is, the implementation of a programme at school and classroom level with the support of an educational authority. Heck, Stiegelbauer, Hall and Loucks (1981) identified three key variables regarding the implementation of a new programme, namely the concepts of Stages of Concern, Levels of Use, and Innovation Configurations that a change facilitator (anyone responsible for assisting users in implementing an innovation) can use to conceptualise the progressive actions of the users. 'Stages of Concern' addresses the person's perception, feelings and motivations relative to the innovation, while the 'Level of Use' focuses upon the behaviours of the individual as he or she approaches and uses an innovation. 'Innovation Configurations' refer to the variations or different patterns of an innovation which occur when it is put into practice by the users (Heck et al., 1981).

Concerns, representing the users' feelings, understanding, motivations, attitudes and Level of Use regarding the particular topic under study, could both be used diagnostically to

determine the type of assistance the teachers need to implement the use and development of science process skills successfully as described by the NCS.

3 EVALUATION

Many definitions of the evaluation process can be found in the literature but a well known definition is that of Ralph Tyler (as cited in Brinkerhoff, Brethower, Hluchyi & Nowakowski, 1983), who perceives evaluation as a process of determining to what extent the educational objectives are actually being realized. Stufflebeam and Shinkfield (2007), for example, defined evaluation as a systematic study that is designed, conducted and reported in order to assist a client group and/or improve the worth and/or merit of some object. Nevo (1995) refers to this definition as an act of collecting information regarding the nature and quality of educational objects.

Stufflebeam and Shinkfield (2007) distinguish between four types of evaluation, namely context, input, and process and product evaluation, also known as the CIPP model. The core concepts of the CIPP model are clearly explained in Chapter One. As previously mentioned (Chapter One), this particular research is based on the assumptions of process evaluation in Windham and Chapman's (1990) terms.

4. THE NATIONAL CURRICULUM STATEMENT (NCS) FOR NATURAL SCIENCES

The NCS was introduced to bring about fundamental changes to the teaching of Natural Sciences in South African primary schools. These changes in particular emphasize science learning for all learners in South Africa and a paradigm shift from the traditional approach of teaching science, namely, an approach that placed greater focus on the mastery of content and

rote learning to an approach that is more innovative, creative, problem-orientated and learner-centred based on inquiry learning that finds its origin in the Nature of Science (Taylor & Vinjevold, 1999). Inquiry-based learning as outlined by the NCS for Natural Sciences has been adopted and revised by most states around the world (King, Shumow, & Lietz, 2001). This new approach to science education in our country encourages learners to explore the world and to question it (Fraser & Onwu, 2006). These questions according to Roehrig et al. (2007) should be driven by scientifically oriented questions that lend themselves to empirical investigation, and lead to the gathering of data to develop explanations for scientific phenomena and allow the learners to gain an understanding of the processes and skills involved in conducting a scientific inquiry, the nature of scientific inquiry and scientific content.

The NCS for Natural Sciences is also structured around the achievement of three Learning Outcomes (LO), namely:

LO1: Scientific Investigations

LO 2: Constructing Science Knowledge

LO3: Science, Society and the Environment

The development of science process skills and inquiry-based learning are applicable to all three Learning Outcomes (DoE, 2002). Despite being important in all three LO's, the focus or bulk of science process skills can be found in LO1 since it is associated with the planning of investigations and with the analysis of results from investigations (Fraser & Onwu, 2006). Therefore, this study finds its context in LO1 (Scientific Investigations) since investigations are of particular importance as they emphasize the use of different process

skills and are at the heart of primary science because they provide first-hand experience, the channel through which a great deal of learning takes place in the early years (Harlen, 2000). The emphasis is on learners developing the ability to ask questions about specific phenomena and from there developing a hypothesis which might explain the phenomena. Then the learners would plan and carry out an investigation and use the results and conclusions to support or disprove the original idea (Rowland, 1992).

Therefore, educator readiness and preparation to deal with these changes is the key to ensuring that the ideals of the curriculum are realized and if educators are to respond meaningfully to the challenges of the new curriculum, they have to have an incisive understanding of the effected changes and much clearer views of these changes (Kriek & Basson, 2008). One of the changes that influenced the perception of science education in our country is the changing view of the Nature of Science.

5. THE NATURE OF SCIENCE (NoS)

Teaching and learning of/in science are reflected in the nature of science itself and in the many definitions that have been formulated over the years (Wessels, 1998). One of the most prominent definitions is that of Renner (as cited in Wessels, 1998, p. 11), who stated that science is “a quest for knowledge”, and not the knowledge *per se*.

This study, despite the many variations in definitions, was based on the definition provided by the NCS (2002), since it describes what aspects of the nature of science educators need to be able to teach their learners in the South African primary school. The definition provided by the NCS (2002) views learning science as “the search to understand the nature of the world through observation, communicating, evaluating, codifying and testing ideas and

has evolved to become part of the natural heritage of all nations" (NCS, 2002, p. 4). The NCS (2002),states further that science is usually characterized by the possibility of making precise statements which are susceptible to some check or proof. The skills mentioned above are some of the skills that are referred to when the term "science process skills" is used in this study. This assumption is supported by many researchers such as Harlen, (2000), Akerson, Cullen and Hanson (2009) and Dreckmeyer (1994). Harlen (2000, p. 7) for example expresses the characteristics of science as a "human endeavour" to understand the physical world by producing knowledge which is tentative and always subject to change by further evidence. Harlen (2000) concurs that science builds upon knowledge and understandings but does not accept it without criticising it. This is often done through observations and explanations of what is observed and the testing of ideas.

Akerson et al. (2009) provide some recent thinking and research about the nature of science and state that:

- scientific knowledge is both reliable (one can have confidence in scientific knowledge) and tentative (subject to change in light of new evidence or reconceptualization of prior evidence)
- no single scientific method exists, but there are shared characteristics of scientific approaches (e.g. scientific explanations are supported by, testable and against, empirical observations of the natural world)
- creativity plays a role in the development of scientific knowledge
- there is a crucial distinction between observations and inferences

- although science strives for objectivity, there is always an element of subjectivity (i.e. it is theory laden) in the development of scientific knowledge and
- cultural and social context play a role in the development of scientific knowledge.

Dreckmeyer (1994) further expands the view of the NoS to include the idea that science, in general, "entails a body of knowledge (content) regarding reality and a process of acquiring this knowledge (p. 11)." This vast body of knowledge is continually expanded and adapted in the scientist's never-ending quest for knowledge.

6. CONCEPTUAL AND PROCEDURAL UNDERSTANDING

According to the DoE (2005), the Natural Science's learning area places investigations and problem-solving at the centre of the classroom activities. It clearly states that each kind of problem and investigation calls for conceptual and procedural understanding (i.e. creative and critical thinking and systematic testing of ideas).

Concerning the development of conceptual and procedural understanding as required by the DoE, Gott and Duggan (1995) have developed a model (see Figure 1) which is applicable to the science curriculum and not solely for practical science. It shows the cognitive (thinking) processes as involving and interacting with conceptual and procedural understanding.

In order to make the implications of the model clear to the reader it is essential to define the terms used in it.

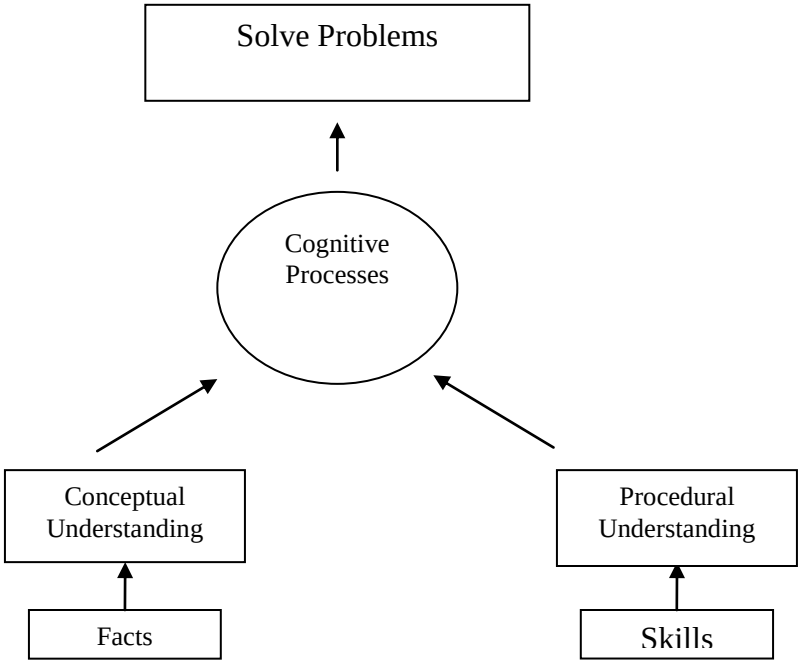

Figure 1. A model for science (extracted from Gott & Duggan, 1995, p. 25).

6.1 Solving problems

As mentioned in the previous paragraph this model is not confined to practical science only. To retain this position a problem includes any activity that requires a learner to apply his or her understanding in a new situation. This include explanations of phenomena, applied science problems, theoretical problems as well as what will be defined as investigations (Gott & Duggan, 1995). Problems posed to the learners should be new and challenging and force the learners to evaluate and modify their own mental structures as the new information becomes available (Burns, 1982). Boshoff (2002) cautions that if a problem is so easy that learners know how to obtain the answer immediately, there is no problem at all.

6.2 Conceptual understanding and facts

In Gott and Duggan's model (1995), conceptual understanding refers to the understanding of ideas which are based on facts, laws and principles and which are sometimes referred to as substantive or declarative concepts. Examples of these understandings include energy, the laws of motion, solubility and photosynthesis (Gott & Duggan, 1995) and could be developed via teaching in the learning process (Webb & Glover, 2004).

6.3 Procedural understanding and skills

The skills referred to here are activities such as the use of measuring instruments and the construction of tables and graphs while procedural understanding is the understanding of a set of ideas which are complementary to conceptual understanding but are related to the 'knowing how' of science (Gott & Duggan, 1995). Procedural understanding is concerned with situations such as if children want to find out which of a collection of play balls is the bounciest, they have to carry out a fair test. This will involve not only the conceptual knowledge of how to conduct a fair test, by identifying and controlling variables, but also the ability (i.e. procedural knowledge) to devise and use a method for measuring accurately how high each ball bounces (Gott & Duggan, 1995). Without this kind of knowledge and practical ability the most ingenious ideas can never be tested and evaluated (Wenham, 2005).

6.4 Cognitive processes

Conceptual and procedural understanding cannot be totally independent of one another: some understanding of science concepts is necessary to carry out most aspects of science, and similarly procedural understanding is necessary to put scientific concepts into practice (Webb & Glover, 2004). These cognitive processes as outlined in the model refer to the interaction

involving the selection and application of facts, skills, conceptual and procedural understanding and are the means of obtaining or processing the information needed to tackle a problem successfully (Gott & Duggan, 1995).

7. THE ROLE OF SCIENCE IN TEACHING SCIENTIFIC LITERACY

The NCS states boldly that the Natural Sciences Learning Area should deal with the promotion of scientific literacy, an endeavour viewed by the NCS as an understanding of how science works and how new knowledge is generated. It also states very clearly that for South African learners to reach this status, namely scientific literacy, learners need to be afforded opportunities to:

- develop and use science process skills in a variety of settings
- develop and apply scientific knowledge and understanding, and
- appreciate the relationship and responsibilities between science, society and the environment.

Scientific literacy has become the term used to express the broad and encompassing purpose of science education (Bybee, McCrae & Laurie, 2009).

It is supported by the National Research Council (NRC) (as cited in Sullivan, 2008), the organization that has produced the national standards for science education in the USA. It states that there is a widespread agreement within education and the broader community that the goal of science education should focus on the development of scientific literacy. This goal, according to the NSSE (1992), could be achieved by providing learners with a specific understanding of the natural world through knowledge of the basic concepts of science,

scientific modes of inquiry, the nature of scientific endeavour and the historical, social and intellectual context within which science is produced. Webb and Glover (2004) further support the promotion of scientific literacy and are of the opinion that science at school level has to cater for two groups, that is, those who will study science at an advanced level, and those who will not. This means that science must be a sound preparation for those who will study further and ensure scientific literacy for those who will not. For this type of learning to occur, the NSES (as cited in Goodnough, 2001) suggests that students should gain not only an understanding of the theoretical and conceptual principles of science, but also develop an understanding of the nature of science and of the complex interplay amongst science, technology, society and the environment, in addition to developing skills of scientific inquiry. Similarly, Lawson (2010) suggests that teaching of science should start with questions about the nature of science, engage students actively, concentrate on the collection and use of evidence, not separating knowing from finding out and de-emphasize the memorization of technical vocabulary.

Thus, this study focuses on the first aim, namely the use and development of science process skills at classroom level. But, before embarking on the nature of science process skills, a short overview of inquiry-based learning will be given, the teaching strategy that promotes the use and development of science process skills.

8. INQUIRY-BASED LEARNING

To be accepted as science, certain methods of inquiry are generally used (NCS, 2002). For this reason, inquiry-based learning has been viewed as the cornerstone of the current reform efforts with regards to the teaching of science education in South Africa. This form of

active learning is an important concept in science education since it plays an important role in the deployment of science process skills in striving to make sense of events and phenomena in the natural and man-made world around us (Harlen, 2009). Inquiry is a multifaceted activity according to the NRC (as cited in Harlen, 2009) that involves making observations, posing questions, examining books and other sources for information to see what is already known, planning investigations, reviewing what is already known in the light of experimental evidence, using tools to gather, analyse and interpret data, proposing answers, explanations and predictions and communicating the results. This definition according to Harlen (2009, p. 6) "is widely quoted". It correlates well with the NCS's view of inquiry-based learning since the NCS for Natural Sciences in South Africa has identified the following phases in the inquiry process: observing and comparing, questioning, predicting, conducting investigations and collecting data, recording results and evaluating and communicating results. Dawson and Venville (2007) further extend the notion of inquiry-based learning to include the notion that learners learn by inquiry when learning is focused on 'finding out'.

Teaching science through processes of inquiry may improve the learners' creativity, reasoning skills, conceptual knowledge, intelligence as well as their general academic achievement (Lawson, 2010) since this approach does not focus on the results of knowledge, concepts, laws, principles and theories, but also allow learners to gain an understanding of scientific inquiry and scientific content knowledge (Dreckmeyer, 1994). But, teaching in discovery and inquiry modes "runs the risk of disorder" according to Martin (2003, p. 344) who is of the opinion that only the most courageous educators are willing to take that risk. Martin (2003, p. 344) states clearly that learners will talk with each other, try out different

things, argue and pursue their position. Although learners often seem to be ‘off task’, learners who are interested in what they are doing are ‘on task’.

The works of Wu and En Hsieh (2006) illustrate that, due to the nature of the inquiry, some investigations do not involve all the processes. For example, analysing data from a weather data base and constructing explanations of phenomena such as global warming and climate change could be an interesting project for inquiry, although learners do not collect empirical information data by themselves nor do they carry out hands-on experiments.

9. RESEARCH INTO THE EDUCATORS’ UNDERSTANDING OF SCIENCE PROCESS SKILLS

There are at least three major domains of educators’ professional knowledge: subject matter knowledge; general pedagogical knowledge (knowledge of the learner, class management learning and instruction, curricular knowledge, knowledge of educational philosophy) and pedagogical content knowledge (that which contains the best ways, strategies, and means to help students learn or the best ways for the instruction of specific content of knowledge) (Shulman, 1987). Therefore, the use and development of science process skills at classroom level will be influenced by the educator’s views of these domains as well as his/her understanding about the basic skills to be taught, since an educator with a particular understanding of these skills, for example, will consciously or unconsciously shape his or her teaching in line with this understanding or view (Wenham 2005). The danger, according to Wenham (2005), is that this understanding will, in turn, shape the children’s perception.

In support of Wenham's (2005) arguments, Wessels (1998) concurs that what an educator knows is one of the most important influences about what is done in the classroom and ultimately what the children learn. Webb and Glover (2004) for example raise the question about what happens when educators do not have the appropriate understanding of any area of science? Research shows that they cope in ways that impoverish children's learning opportunities (Webb & Glover, 2004). These include:

- Sticking to the areas where they are most confident
- Relying heavily on work cards which give step by step instructions
- Avoiding anything that might go wrong
- Using expository teaching (telling) and
- Not allowing questioning (Webb & Glover, 2004).

For educators to teach these science process skills effectively requires that they should have a good understanding of and be able to identify the different science process skills that make the procedural understanding as well as to plan and provide opportunities for learners to practice these skills individually within activities where learning intentions are related explicitly to the chosen process skills (Ward et al., 2008).

Another factor that influences educators' classroom practices is the belief held by those educators (Roehrig et al., 2007; Lotter, Harwood & Bonner, 2007). A study conducted by Hewson and his colleagues (as cited in Lotter et al., 2007) have shown how educator beliefs of science instruction, science knowledge, and science learning influence educators' use of conceptual change strategies. Educator beliefs are often difficult to change since this belief about their teaching has been formulated over many years of classroom teaching (Lortie,

1975). Although beliefs can persist, they can be changed through intensive one-on-one professional development, over an extended period (Krajick, Blumenfeld, Marx & Soloway, as cited in Roehrig et al., 2007).

10. SCIENCE PROCESS SKILLS IN THE NCS

Science process skills are involved in the processes of interacting with materials and in the processing of information so gained (Harlen & Qualter, 2004). This term, according to the NCS (2002), refers to the learners' cognitive activity of creating meaning and structure from new information and experiences: in other words, learning strategies used in the process of understanding a new situation or in the presentation of it. Additionally, Rezba, Sprague, Fiel and Funk (2003) view science process skills as the basic skills people employ when they do science. They are related to the "…proficiency in using various aspects of science and are associated with cognitive investigative skills (Bilgin, 2006, p. 30)". It is through these skills scientists collect data, put experiments together, analyse data and formulate results. Using these fundamental skills are important for meaningful learning, because learning continues through life and individuals need to find, interpret and judge evidence under different conditions they encounter (Bilgin, 2006). They are also essential in enabling learners to develop understanding and the ability to identify and use relevant scientific evidence in solving problems and making decisions (Harlen, 2000).

Research, including the NSES(as cited in Monhardt and Monhardt, 2006), suggests that science process skills may be one of the most important tools for producing and arranging information about the world around us and there is a strong research base and science education documents that support the teaching of these fundamental skills.

From a teaching point of view these skills should be used in all science activities covering the content, and not as an exception or addition to it (Harlen & Qualter, 2004; Wilke & Straits, 2005; Carin, 1997). Similarly, Millar and Driver (1987) argue that the process approach should be seen as the means involved in learning science concepts and not as the product of science. On philosophical grounds, Millar and Driver (1987), also argue that science process skills such as hypothesis and predictions are intuitive and cannot be learned and transferred.

However, studies such as those of Harlen and Qualter (2004) and Herman (2009) suggest that integrated science process skills could be taught directly to primary school children with some form of training or intervention. Accordingly, the works of Monhardt and Monhardt (2006) also reveal that research has shown that once students have been taught these skills, they are broadly transferable from one situation to another, are appropriate for many science disciplines and accurately reflect the skills used by scientists. Herman (2009) believes that globalization, rapid change, the explosion and specialization of knowledge and the transformation of the nature of work demand the so-called 21st century skills. To help learners to discover new knowledge and to solve problems, a set of science process skills have been outlined by the NCS that learners could use to create meaning and structure to the new knowledge they have gathered.

11. ESSENTIAL SCIENCE PROCESS SKILLS

A set of process skills have been identified by the NCS (2002) which are essential in creating-inquiry based activities. These include observing and comparing, questioning,

predicting, conducting investigations and collecting data, recording results, and evaluating and communicating findings.

11.1 Observing and comparing

"These may involve the learner in noting details 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" (NCS, 2002, p. 13). This is the most basic skill of all process skills and the primary way in which children obtain information (Martin, Sexton, Wagner, Gerlovich, 1994; Monhardt & Monhardt, 2006). The information learners gain from this process skill may lead to curiosity, interpretations about the environment and further investigation. It may also lead to the development of other science process skills such as inferring, communicating, predicting, measuring and classifying (Ward et al., 2008; Rezba et al., 2003).

11.2 Questioning

"Science is concerned with investigable questions, ones which can be answered by scientific enquiry (Harlen, 2000, p. 35)." Therefore, raising questions about a situation involves thinking of questions which could be asked about the situation, recognizing a question which can be answered by scientific investigations (as opposed to a question which science cannot answer), or re-wording the question to make it investigable (NCS, 2002). Asking investigable questions could be useful, since these questions show gaps that the children feel they need to fill in their understanding, they can provide the basis for children's investigations and they give children the opportunity to realize that they can find things out for themselves and satisfy their curiosity (Harlen & Qualter, 2004).

11.3 Predicting

"Predictions are statements about what might happen or could be expected to happen in the future" (Wenham, 2005, p. 12), but they should be based on some relevant prior knowledge in a form which can be investigated (Rowland, 1992). A prediction is therefore not a wild guess. It has been said that the most important question elementary science educators can ask their learners is, 'What would happen if . . . ?' When this question is asked, it seems to require an answer. These 'What would happen if?' questions stem from observations, interpretations and curiosity, or pre-existing knowledge which might lead to a question that someone wants to investigate. These are the processes involved when making a prediction (Martin, 2003). In this way children learn to compare what actually happens with what they thought would happen, rather than merely accepting what happened without thinking about it. The discrepancies between predicted and actual occurrences are areas worthy of further investigation. For example, if a child predicts that a coin will not be attracted to magnet and then finds out that it is not attracted to magnets, the child may want to investigate why this is not.

11.4 Conducting investigations and collecting data

The learner carries out instructions and procedures involving a small number of steps. H/she follows a simple worksheet to set up equipment in order to observe and collect data as the investigation purpose requires (NCS). Conducting an investigation is a complex process skill that requires the learners to persevere until the phenomena happen, using observations, collecting and analysing data and drawing conclusions in order to solve a problem situation

(Martin et al., 1994). The idea of teaching science as an investigative discipline is a core tenet because:

- it reduces the emphasis on drilling and memorizing
- increasing the emphasis on applying knowledge to the students environment
- fostering scientific reasoning
- promoting scientific literacy among all children and
- tailoring instruction to student's prior knowledge and emerging understanding (King et al., 2001).

11.5 Recording results

Learners' recording is their own communication of ideas and understanding using a medium that can be saved and stored (Ollerenshaw & Richie, 1997). It may also involve the learner in recording on a form which is prescribed (sentences, lists, tables, labelled diagrams), 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 educator (NCS, 2002). Any form of recording, according to Ollerenshaw and Richie (1997), has many functions, such as:

- it can help the learner to clarify his or her thinking
- it can be used as a personal record by the learner
- it can be used as a vehicle for discussion between the teacher and the child
- it can be a source of evidence of educator assessment and
- it can contribute to a child's portfolio or profile.

11.6 Evaluating and communicating results

The skill of evaluating and communicating results needs to be mastered as a process skill when learners report on the group's procedure and the results obtained. This process skill may also involve a situation in which the learner comments on observations and responds to the focus question. When learners have completed an investigation it is important that they reflect on the procedure and experimental design by identifying the difficulties they experienced in doing the investigation and reflecting on how they could improve the same investigation in terms of fairness and accuracy (Dawson & Venville, 2007; Harlen, 2000 & Ward et al., 2008). Ward et al. (2008) concurs that this process skill allows the learner to actively evaluate their own and others learning.

Communicating can take many forms including using words, actions, posters, diagrams, pie-charts or graphic symbols to describe an action or event (Monhardt & Monhardt, 2006). Monhardt and Monhardt (2006) also state that it requires learners to share the information they have gathered from observations with the rest of the class. This process skill helps the learners to reflect on their own learning and to build confidence as a person (NCS, 2002).

On the surface the above process skills may appear to be reasonably uncomplicated, but the complexity comes in during the implementation in the primary school classroom during the Natural Sciences lesson.

12. HINDRANCES TO IMPLEMENTATION

As stated earlier in the chapter, the NCS was introduced to bring about fundamental changes to the teaching of Natural Sciences in South Africa. However, implementation was hindered by the lack of resources (e.g. the lack of equipment to do experimental work,

shortage of textbooks and inappropriate furniture), monitoring of the implementation of policies as well as the lack of continuous professional support (Kriek & Basson, 2008). These changes were further complicated due to the educators' lack of understanding of the terms used in the Natural Sciences policy documents (Saunders & Nduna, 2006) as well as the educators' view of the nature of science since many educators in South Africa view themselves as transmitters of information (Webb & Glover, 2004). Webb and Glover (2004) concur that it is a very complex phenomenon to change the educators' view of teaching science in South Africa since they believe that there is a system of rules which needs to be taught directly (transmission view) or camouflaged in practical activities (empirical view). Saunders and Nduna (2006) argue that with the implementation of the NCS, educators struggled to identify from official documents what exactly it is that the new curriculum requires science teachers to do. They state that nowhere do the policy documents provide comprehensive guidance. Additionally, terms were often used in the policy documents without clearly explaining what the terms mean. Blignaut (2009, p. 5) states that "…if educators do not feel a sense of identification with policy its goals may be undermined by practitioners." Such conditions, according to Shalem and Slonimsky (as cited in Blignaut, 2009), create a facade (an appearance that is false) of reform as educators ignore or even resist what is asked of them.

Furthermore, studies conducted on primary science education by researchers such as (Murphy, 2009; Peacock, Serret & Lindsay, 2009; Sharp & Hopkins, 2007) view the lack of confidence and knowledge of a number of educators when teaching science as well as the lack of appropriate professional development as major constrains in pursuance of the implementation a new programme. One critical concern highlighted by Sharp and Hopkins

(2007) is the fact that some educators feel less prepared to teach science through inquiry. Sharp and Hopkins (2007, p 12) further state that although the constraints mentioned above were cited by many researchers "certain issues (obstacles and hindrances) remain unresolved, and the status of primary science remains problematic."

To cope with curriculum reform and to deal with the obstacles mentioned above , it is important that educators are supported and developed in a professional manner since they (educators) play a pivotal role in the successful implementation of a new curriculum (Fullan, 2007). Support or rather lack thereof, according to Blignaut (2009), is one of the most common cited reasons why educational innovations fail.

13. SUPPORT

The support could be provided from responsible bodies such as the government, district office and managers (Kriek & Basson, 2008) since providing personal and professional development is viewed by many educators as highly supportive (Hord, 1995). Developing the educators' capacity on a continuous basis is necessary according to Dreckmeyer (1994) due to the rapid progress in the development of science and teaching practices. He suggests that curriculum planners should create opportunities in which educators make contact with their colleagues and experts in their field of study. In order to achieve such contact, educators should avail themselves of opportunities to attend regional and national conferences, well conducted workshops and in-service training courses to broaden their knowledge of the subject as well as of possible new instructional and learning strategies to science. These workshops and in-service courses, according to Goodnough, (2001), should be directly linked to the educators' work in their classrooms and schools and should build on their current

beliefs, knowledge and understanding while Fullan (2007, p. 30) states that teacher development involves "change in practice." Data on science educator concerns should also be taken into account when agendas for workshops or in-service courses are planned. Assessing the educators' concerns provides information about their needs and shortcomings. This information could be used to provide appropriate assistance. When appropriate assistance is provided, educators are to a certain extent compelled to act in accordance with policy since many excuses might be eliminated from the table (Hord, 1995). For instance, if an educator does not have the appropriate knowledge of how to implement the development of science process skills, curriculum leaders can than provide information on this problem, demonstrate how it might be done or may arrange visits to other schools or classrooms so that educators can see how others have managed it. Fullan (2007) further emphasize the importance of assistance and resources and maintains that these should be provided in such a manner that teachers should feel the pressure to improve.

CHAPTER THREE

RESEARCH METHODOLOGY

1. INTRODUCTION

This chapter presents the methodology employed to generate data for this study. This includes a brief description of both qualitative and quantitative research methods. In addition, the methods and procedures used to collect data, different data collection instruments and the strategies employed to analyse the data are described. Lastly, issues such as validity and ethical considerations regarding the research process are discussed.

2. RESEARCH DESIGN

A research design is a plan or blueprint of how one intends conducting the research (Mouton, 2001). The purpose of this study is to evaluate the extent to which the use and development of science process skills are being implemented in the teaching and learning of Natural Sciences for grades 4 - 7 learners at a primary school, which will be known as Mzanzi Primary. Given this purpose, a case study design was used to gather relevant and appropriate information about the educators' classroom practices with respect to implementation of science process skills. A case study, according to Mouton (2001), is qualitative in nature, exploratory, descriptive and aims to provide an in-depth description of a number of small cases. Brown and Dowling (1998) view a case study as an endeavour that focuses on a single actor, a single institution, a single enterprise usually under natural conditions, in order to understand it. Since a case study provides an "in-depth description" (Mouton, 2001, p. 149)

of the cases, a variety of data collection techniques as described below were employed to build a picture of each educator's practices.

Firstly, an extensive literature study on the subject of evaluation, implementation as well as appropriate literature related to science process skills was undertaken. Following the literature study, qualitative measures such as semi-structured interviews (see Appendix A), classroom observations (see Appendix B) and group interviews took place in an attempt to develop a richer understanding of the educators' understanding of science process skills and how this understanding was practised in the Natural Sciences classrooms. To support and strengthen the qualitative data, quantitative measures (see Appendix B and Appendix C) were designed to evaluate the extent to which the use and development of science process skills were applied by the educators in their science lessons as well as the extent to which the assessment activities reflected the practices of science process skills as outlined by the Provincial Assessment Guideline for Natural Sciences (2007).

However, this study was conducted at an average primary school in the northern areas of Port Elizabeth. This area has a high rate of unemployment and signs of economic and social distress are clearly visible as unemployment has increased. School records indicate that 58% of the learners depend on the school's nutritional programme and approximately 49% receive social grants. These statistics indicate that the learners in this school do not come from financially stable homes.

3. SAMPLING

Four educators (one male and three females) from Mzanzi Primary School participated in this study. Three educators were selected from the intermediate phase (one teacher from

each grade in the phase, namely grades 4-6) and one educator from the senior phase (viz. grade 7). The educators were invited in writing and agreed to participate voluntarily, provided that certain conditions were met. These conditions were, firstly, that their names not be mentioned in the study and secondly, that none of the information be reported to the principal. They received the assurance that pseudonyms would be used, that all data collected would be treated confidentially and that neither the school, learners or participants would be identifiable in any reports that are written. Therefore, in this research project the grade 4 educator is referred to by the pseudonym of Amanda, the pseudonym David is used for the grade 5 educator and Vuyokazi for the grade 6 educator. The grade 7 educator is referred to as Phumeza.

The educators were selected purposively, because of the qualities they could bring to the study as well as for practical reasons (Lankshear & Knobel, 2004), Firstly, easy access was facilitated, because both researcher and participants are at the same school and there were thus no travelling costs involved. The purpose for selecting these educators was based on their willingness to be interviewed and observed as well as the fact that these educators had attended NCS workshops and cluster meetings for Natural Sciences. Among the participants, Amanda and David's selection was deliberate due to their interest and motivation to improve their classroom practices in Natural Sciences. Both these educators are currently part-time B.Ed students specialising in Science and Mathematics at the Nelson Mandela Metropolitan University (NMMU). Amanda is in her first year and David in his final year (2010). David did exceptionally well and is amongst the top 15% academic achievers at the University. On the grounds of this achievement, he has been invited by the University to join the Golden Key International Honour Society. Additionally, these four educators have taught at this school

for more than fifteen years and have had much experience in managing classrooms that are increasingly diverse in terms of ethnic, linguistic and cultural backgrounds. These challenges and demands require special capacities and knowledge from the educator (Darling–Hammond, 1998).

4. DATA COLLECTION

Collection of data is necessary to obtain information that will provide answers to important questions (Johnson & Christensen, 2004). According to Mouton (2001), the most common data collection methods that are used by educational research are tests, questionnaires, interviews, focus-group interviews, observations as well as primary and secondary sources. For the purpose of this study, the following methods were employed: literature review, interviews, observations, focus-group interviews and the learners' assessment activities.

5. INTERVIEWS

Semi-structured interviews which were held between April and June 2010, (see Appendix A), as described by Johnson and Christensen (2004), were designed to develop a greater understanding of the educators' understanding of science process skills, their current practices with respect to the implementation of these basic skills, their perceived impediments to implementation as well as the support educators need to improve their practices with regard to the teaching of these basic science process skills. Johnson and Christensen (2004) point out that qualitative measures, such as interviews, allow researchers to enter the inner world of another person and to gain an understanding of that person's perspective. The educators were

also asked to comment on their own educational background to see whether there was a correlation between their current practices and the manner in which they had been taught.

Each educator participated in a semi-structured interview consisting of a series of prescribed questions. The interviews were conducted between March 2010 and May 2010. Informal discussions between the educators and the researcher in and outside the classroom were also regarded as a form of interview. The interviews were conducted in Afrikaans, except the one with Vuyokazi, the grade 6 teacher who preferred English. The interviews lasted between 25 and 30 minutes. The dates for each interview were determined by each educator.

Vuyokazi and Phumeza struggled to answer the first research question but responded well to the other four questions. David and Amanda responded very well to all the questions. Permission was obtained to take notes as the researcher made his observations. In conclusion, Johnson and Christensen (2004) state that the interview should be friendly, and that the researcher should be impartial to whatever the interviewee says to him/her. They maintain that if the researcher reacts positively or negatively to the content of the interviewee's statements he/she may bias the responses.

6. CLASSROOM OBSERVATION

Classroom observations were performed to determine whether there was a correlation between the educators' perceived and actual classroom practices with regard to the implementation of science process skills. To develop a richer understanding of how the educators perceived understanding of science process skills was practised, classroom observations were held. All the participants were observed for four lessons of one hour each

in their classes. Access to each educator's classroom was relatively easy. Initially the intention was to observe five lessons, but due to time constraints and other contextual factors it was not possible. These observations took place between June 2010 and September 2010. Notes were taken during each class visit. These notes were descriptions of what happened in the classroom, for example, the type of learning strategies the educators used in their classrooms and discussions between educator and learners and between educator and researcher. As an observer the researcher tried to be objective and not get involved in the dynamics of the classroom.

The purpose of classroom observation in educational research, according to Johnson and Christensen (2004), is to observe the educators in their natural settings as it normally occurs. Much can be gained by observing the interaction between educator and student, materials, problems and procedures (Lewy, 1979).

7. FOCUS-GROUP INTERVIEW

At the final stage of the data collection process a focus-group interview was held to briefly discuss the participants' assessment practices as described by Johnson and Christensen (2004) who state that focus- group interviews are useful for providing in-depth information in a short period of time. The interview was structured around the following: the educators' understanding of the Common Assessment Tasks (CAT) and how these were utilised to assess the learner process skills, their current assessment practices and how educators can be supported to improve their assessment practices regarding the CATs. Finally, the educators were also challenged as outlined by Mouton (2001) to re-evaluate a previous position or statement that was in need of amplification, qualification, amendment or contradiction.

The educators were informed about the group interview well in advance as well as its purpose. The interview was led by the researcher who tried to keep the group focused on the topic being discussed since the educators had a lot to say about their current status. Before the commencement of the interview, the topic to be discussed was introduced as well as the other elements related to the topic. The questions were presented on a sheet of paper. A period of 40 - 50 minutes was set aside to discuss the questions. David was appointed to take notes and Vuyokazi was asked to give the report back. Although Vuyokazi gave a comprehensive report back, the other three educators also voiced their opinions just to consolidate their statements. Informal discussions between researcher and participants also took place after formal group interview. These comments were also recorded.

8. LEARNERS' ASSESSMENT ACTIVITY BOOKS

The Natural Sciences learning area should have six formal common assessment tasks, also known as CATs, per year in grades 4 - 6. In grade 7 there should be eight assessment CATs, according to the Provincial Assessment Guideline for Natural Sciences (2007). Tasks should reflect the following forms of assessment: investigations, assignments, research projects, case studies, controlled tests and examinations and should be designed to assess a range of science process skills and competencies (Provincial Assessment Guideline for Natural Sciences, 2007). The recorded evidence will be used to decide whether learners should progress or promoted to the next grade.

To ascertain the type of CATs that were employed by the educators to assess the learners' science process skills as outlined by the Provincial Assessment Guideline for Natural Sciences (2007), twelve assessment activity books were randomly selected from each

class. An Assessment Activity Science Process Skill–Rating scale (see appendix C) was used to assess the activities. These activities were examined at home by the researcher. Notes were also taken to provide a picture as to how the learners used the different science process skills to solve a problem or to make decisions. The notes included descriptions of the manner in which the learners answered the research questions, the way in which the learners described an event that had been observed, the predictions they made, the formats used to record the data and lastly, the manner in which the learners constructed explanations, manipulated content and drew appropriate conclusions.

After having viewed the learners' assessment activities thoroughly it could be deduced from the manner in which the learners conducted the investigations, that most of them did not have a clear understanding of the research question and certain concepts associated with the topic under investigation. Furthermore, it was also observed that they battled to describe their observations in writing. Spelling and proper sentence constructions are of great concern. Nor were some of the learners able to use an appropriate format to record the information they had gathered from the investigation. Learner independence to promote predictions were not evident although they were requested to make predictions during the teaching activities. One of the greatest barriers that was observed from these assessment activities was that the learners have difficulty in interpreting, constructing explanations, manupilating and drawing appropriate conclusions about the data to which they were exposed

9. DATA COLLECTION INSTRUMENTS

As mentioned in Chapter One, qualitative research methods were the central data gathering method used to gain a richer understanding of the participants' understanding of science process skills and how this understanding was applied in their classroom practices. Detailed notes were taken to record the qualitative data as the events took place. In an attempt to obtain deeper insight and understanding of the qualitative research methods, quantitative research measures were performed.

Quantitative data were collected from a Science Process Skill Observation-scale (see Addendum B) and an Assessment Activity Science Process Skill Rating-Scale (see Addendum C). These instruments were designed by the researcher. The Science Process Skills Observation Scale was designed to measure the degree to which the use and development of science process skills were applied by the educators in their Natural Sciences lessons. An observation sheet was completed for each educator. The instrument assessed the following descriptors regarding the implementation of science process skills: observing and comparing, questioning, predicting, conducting investigations, collecting data, recording results and evaluating and communicating results. The descriptor used by each teacher was marked. Each descriptor was rated on a scale of 1 to 4 (viz. 1 = not seen, 2 = performed satisfactorily, 3 = performed well, and 4 = performed in an outstanding and advanced manner). The Assessment Activity Science Process Skill Rating-Scale assessed the extent to which the assessment activities reflected the practices of science process skills as outlined by the NCS for Natural Sciences. A rating scale was completed for each assessment activity. The instrument assessed six descriptors in relation to the assessment of science process skills, namely, the extent to which the learners related to observations and investigable questions,

how they responded to ‘what if’ questions, whether they conducted scientific investigations and collected suitable data, recorded the data, interpreted the data and lastly, drew appropriate conclusions from the data. The descriptor employed to assess the learners’ science process skills was marked. Each descriptor was rated on a scale of 1 – 4 (1 = having difficulty, 2 = fair, 3 = good, 4 = outstanding).

10. DATA ANALYSES

Owing to the qualitative nature of the study, data were analysed on a daily basis. Emerging patterns and prevailing practices from the qualitative research methods were recorded according to each participant’s response in order to give appropriate and relevant descriptions about the educator’s views, perceptions and practices regarding the topic under study. The analysis of data helped the researcher to gain an understanding of the social world of each participant in terms of their experiences, perspectives and perceptions.

The quantitative data were analysed through the computation of individual frequencies that showed the total tallies, which is the number of times something happened (Heck et al., 1981). The frequency used within a descriptor was tallied. Raw tallies then illustrated to what extent the use and development of science process skills were employed by each educator.

11. VALIDITY AND RELIABILITY

Validity refers to the degree to which a study reflects on the specific concepts the researcher is attempting to measure (Brown & Dowling, 1998). Four data sources were accessed, namely interviews, classroom observation, focus-group interviews and perusal of

learner assessment activity workbook. The data collected from each of these sources were responses to questions concerning process skills (see Appendices A, B and C).

The reliability and validity of this study were increased by the use of multiple methods commonly referred to as triangulation in the literature. The different methods afforded the researcher the opportunity to view the data from different angles. The four sources used for this triangulation represented different styles and methods of data collection, namely individual interviews, classroom observation, interviews and workbooks and reliability of the data can be determined by attempting to identify common threads or trends in the educators' responses to these collection instruments.

To increase the reliability and validity of this study, the four educators were given the opportunity to read the information collected from them to check whether the interpretation of their statements needed to be amended or rephrased. Without such a process a researchers' "interpretive framing of the educators' stories of their experiences could raise grave concerns about the validity of the research" (Blignaut, 2005, p. 118).

12. ETHICAL CONSIDERATIONS

Much social research necessitates obtaining the consent and co-operation of participants who are to assist in investigations and of significant others in the institutions or organisations providing the research facilities (Cohen & Manion, 1994). Therefore, before the research journey was started, a letter was written to the District Director of the Eastern Cape Education Department requesting permission to conduct the research at Mzanzi Primary. Furthermore, informed consent was also obtained from the principal of the participating school as well as from the educators of the school. The educators were informed that their participation was

voluntary and assured that their identity would not be revealed and that they could withdraw at any time of the project should they choose to. Additional information such as the purpose of the study, the processes involved and their role as participants were highlighted.

13. LIMITATIONS TO THE STUDY

The study was limited to one school in the northern areas of Port Elizabeth. The small sample from the school, namely Mzanzi Primary cannot be considered to be a true reflection of all the schools in the in the northern areas of Port Elizabeth and therefore cannot be generalized to all the schools in South Africa. Though, the information could be utilised to raise questions and to initiate debate regarding the implementation and development of science process skills at classroom level.

In Chapter Four the results of this study are presented and discussed.

CHAPTER FOUR

RESULTS AND FINDINGS

1. INTRODUCTION

This chapter reports on the data generated in this study. The study generated both qualitative and quantitative data from four educators, namely, Amanda, David, Vuyokazi and Phumeza[2]. Firstly, qualitative data were collected from interviews (see Appendix A), focus-group interviews as well as from classroom observations and secondly, quantitative data were collected from the Science Process Skill Observation- Scale (see Appendix B) that measured the degree to which the use and development of science process skills were applied by the individual educators in their science lessons. Furthermore, an Assessment Activity Science Process Skill Rating- Scale (see Appendix C) was used to assess the extent to which the assessment activities reflected science process skills as described by the NCS. The quantitative data were analysed through the computation of individual frequencies that illustrated the number of tallies, or the number of times an event happened in the classroom.

2. INTERVIEWS

The four educators were interviewed (see Appendix A) before each classroom observation. The interviews took place between April and June 2010 and focused on the following with respect to each educator:

[2] These are not the actual names of the educators.

- their understanding of science process;
- the extent to which they used science process skills in their classrooms;
- their perceived impediments to implementation of science process skills;
- suggestions from them as to how they could be supported to improve their classroom practices with regard to the teaching of science process skills, and lastly
- comments on their own educational background and experiences relating to Natural Sciences.

2.1 Educators' understanding of science process skills

The first question that the interview focused on was the educators' understanding of science process skills. Responses to this question varied, with the grade 4 educator, Amanda, viewing science process skills as the skills the learners use when they do science and she associated the development of science process skills with 'hands-on' experiences, critical and creative thinking. She stated that her studies in Science and Mathematics at the NMMU had influenced this understanding. She eloquently pointed out: "The poor training programmes I received from the DoE did not change any of my science practices." Furthermore, she was of the opinion that science process skills should not only be confined to Natural Sciences, but that these skills should be developed in Mathematics during mathematical problem-solving or in a Learning Area such as Life Orientation, when the learners carry out investigations such as in the example that she mentioned: "the investigation of a refuse dump site." The second interviewee, David, a grade 5 educator, described science process skills as the skills the learners use when they conduct an investigation or solve a scientific problem. He also pointed out that "science process skills are related to predictions, observations and the

recognition of patterns and inferences." The remaining two teachers, Vuyokazi and Phumeza, grade 6 and grade 7 educators respectively, appeared to have a limited understanding of science process skills. When prompted to give an example of a science process skill, neither was able to do so. One of the problems associated with the lack of understanding is that if educators' do not have an appropriate understanding of the processes of science, they cope in ways that impoverish children's learning opportunities (Webb & Glover, 2004).

2.2 Views on current practices related to science process skills

Amanda regarded herself as a facilitator and as someone who always attempted to employ a teaching approach in her science lessons in which the learners are given the opportunity to make observations, predictions, recognise patterns and make drawings. She said that she always encourages the learners to share their observations with one another, even though it often disrupts the flow of the lesson sometimes. During the interview she mentioned that she uses the Natural Sciences policy document as a guide when she plans her lessons. She made a point of referring to "pages 16 – 20 of the policy document" and claimed that she regards these as important pages because it illustrates and gives the educator an idea of what the learners should do when they are confronted with a problem or when they conduct an investigation. Similarly, David stated that he is an advocate of the "inquiry approach" as outlined by the NCS policy document for Natural Sciences, since this approach plays an important role in the development of higher order thinking and motivates the learners to employ different strategies when they are confronted with a problem. He noted that lessons vary from time to time and as such, some lessons require the traditional approach to teaching in which he imparts information to the learners, while other lessons lean more towards an inquiry approach in which learner independence is promoted in that they are required to use

their senses, ask questions about a phenomenon, seek patterns and make inferences. David also mentioned that he now has a better understanding of inquiry-based teaching due to his studies in Science and Mathematics at the Nelson Mandela Metropolitan University. He claims that he tries to incorporate this inquiry-based approach in his science teaching more than he did before he studied, but he still does not find it easy to use this approach. Unlike David and Amanda who try to employ an inquiry approach, Vuyokazi stated that she relies mostly on the traditional approach[3] in her science lessons in which she primarily imparts information to the learners. Bennet (2003) noted that simply telling or explaining concepts to the learners is no guarantee that they will receive the massage or understand it. During the interview it transpired that the educator structures her science lessons mostly around educator talking and the learners responding to her questions. She feels that her learners learn best through memorisation, an approach that she has used since she started her teaching career and it has never failed her. She said that she makes sure that she is always in control of the content to be learned and that her learners are always up to the task and able to perform it. Vuyokazi felt that her teacher-centred approach was an effective one to use. Phumeza also claimed that she preferred a learner-centred approach in which she guides and then redirect learners' ideas, making science more active, realistic, challenging and developing certain skills as outlined by the Critical and Developmental outcomes. However, she acknowledged that much of her practice involved knowledge transfer with an emphasis on the mastery of content and that this was in a way quite traditional. From the interview it transpired that Vuyokazi and Phumeza believe their learners learn best when the science content is explained to them. They indicated that they are satisfied and pleased when the learners are able to

[3] In this study the 'traditional approach' is one that relies on a teacher dominated approach with emphasis on 'chalk and talk' and textbooks etc.

answer the questions related to the content they had been taught. The beliefs held by these two educators might be considered to contradict a learner-centred approach. Many researchers (Lotter et al., 2007; Roehrig et al., 2007; Webb & Glover, 2004) have found that the so-called traditional approach is very common amongst educators but that these beliefs can be changed through intensive professional development over an extended period of time.

2.3 Impediments to implementation of science process skills

Amanda perceived a number of barriers preventing her from implementing an inquiry approach. Some of her impediments were structural (e.g. lack of science equipment, lack of appropriate furniture and laboratory space) while another group of barriers involved the support of people (e.g. lack of collegiality and support from school colleagues, lack of parental and home support) and lastly, she identified the curriculum as a potential barrier (e.g. the poorly constructed curriculum with respect to content to be taught, the provincial common assessment tasks (CATs).

In describing his primary perceived impediment David stated: “I really do not have much confidence in my learners to describe an event they observed verbally as well as in writing because their descriptions sometimes do not match what actually happened.” The second obstacle identified by David was that when the learners are asked to make a prediction, they merely make wild guesses without thinking. David also mentioned that their lack of interest in science and their lack of general scientific knowledge placed a damper on an inquiry approach. Pupil autonomy and self-responsibility were also highlighted as impediments since the learners need constant guidance with experimental procedures, the reading and interpretation of questions as well as continual reminders to clean their work

space. These factors make teaching via inquiry exhausting and time-consuming and as such it is therefore difficult for him to remain focused and enthusiastic.

Vuyokazi and Phumeza described their lack of understanding of the concept 'science process skills' as well as their lack of confidence as to how to go about teaching these skills as primary obstacles. This concern, namely, the lack of confidence as to how to go about teaching science through inquiry is not only manifested in South Africa. Several researchers (Murphy, 2009; Peacock et al., 2009; Sharp & Hopkins, 2007) have commented on the worldwide problem of educators' confidence or rather lack of confidence to teach inquiry-based science. In an extensive review of the constraints on science inquiry, Murphy (2009) concluded that one of the major issues in primary science teaching that places a damper on inquiry-based learning may be attributed to the educators' lack of confidence in running 'inquiry-driven lessons' and that this lack of confidence could be because of the severe lack of appropriate professional development in this area.

Vuyokazi stated that she has to prepare her grade 6 learners for the common examination scheduled at provincial level for grades 3, 6 and 9. Therefore, letting the learners work in groups and discussing a problem would just take up too much of her teaching time. She feels that she will be held responsible for poor examination results. Vuyokazi also voiced her opinion regarding the terms used in the Natural Sciences document:

"I am not familiar with terms used in the Natural Sciences policy documents and I find it difficult to link the different learning outcomes and assessment standards to the learning content to be taught. If the different terms were explained to us it might have been easier for me to identify what is required from me."

She also expressed similar concerns as those raised by Amanda, namely, lack of resources, inadequate learning materials, educator isolation and the lack of professional discussions between educators on how to improve their science practices. Phumeza, the grade 7 educator, admits that it is difficult to change her teaching habits, that is from a teacher- to a learner-centred approach, with the latter being where the learners are given the freedom to work on their own discussing scientific problems and finding solutions but she feels that they (the learners) need her for guidance in order to gain the necessary knowledge to succeed. Additionally, Phumeza also noted the following impediment: "I am afraid that I might lose control of the class when the learners share and exchange ideas. The noise level during group work is sometimes disturbing and it is difficult to get their attention after a group activity." Martin (2003) commented on this concern (see Chapter Two) and maintains that teaching via inquiry creates an atmosphere of disorder. Phumeza also mentioned that she feels uncomfortable if she is not in control of the learning content as well as of the learners. When the learners notice that she is not at ease, they take advantage of the situation, so instead of venturing into this potential for chaos she ensures good order by relying mostly on questions and answers, explanations, tests and the completion of worksheets. She also expressed reservations about being able to complete the amount of content if she did not adopt a teacher-centred approach.

2.4 Support

All four educators indicated that they were not supported and developed by the Department of Education as they had been promised. The five-day workshops that were presented by the Department of Education were not nearly enough and more training is needed to increase their competencies with regard to the teaching of the Natural Sciences

Learning Area. Phumeza and Vuyokazi in particular emphasised the need for more and effective professional development in Learning Outcome 1 (i.e. Scientific Investigations). When prompted about what is needed to teach science as a process more effectively, the teachers unanimously indicated that learning materials and resources from responsible bodies such as the Department of Education are needed so as to encourage and guide educators to introduce future activities that will reinforce the use and development of science process skills. The sentiment regarding the lack of support and the availability of learning material and resources as highlighted by the educators in this study indicate that these kinds of services need to be accelerated and improved in South Africa. Darling-Hammond (1998) in an extensive overview of educational reform efforts concluded that reform efforts must focus on building the capacity of educators in terms of the content to be taught and how it could be taught best to deal with the changes successfully. Authors such as Fullan (2007) argue that the process of professional development has to be enhanced with high quality teaching and training material.

David proposed that the suggestions made by the teachers concerning their needs and shortcomings should be considered when workshops for Natural Sciences are planned. This might prevent the Department of Education from presenting generic workshops and instead focus more on specific issues as highlighted by the educators. Following this suggestion, Amanda pointed out: “A standard text book for science or a workbook should be provided for each grade since most of the educators are uncertain about what to teach and the level at which they should teach certain topics or concepts”.

2.5 Educators' educational background and experiences related to Natural Sciences

The four educators indicated that they had themselves learned science dogmatically, using rote memorisation of facts, principles and laws. When they were at school and in pre-service training their own science educators had relied heavily on the traditional teaching paradigm since it was considered as one of the most effective approaches. Phumeza stated that her science teacher was always well prepared and had the ability to hold the learners' attention for quite a long period of time. She also mentioned that her science teacher was always in control of the learning content. Vuyokazi mentioned that, although her science teacher did most of the talking and supplied them with information, they were also requested to answer stimulating questions. The educators also said that they had been taught by means of demonstrations and neat wall charts. The wall charts were displayed against the wall after the lesson to beautify the classroom. Additionally, from the interviews it transpired that the science educators of these four educators had always been well organised and that their current practices are influenced by the way they had been taught in the science classroom.

3. CLASSROOM OBSERVATION

Before the commencement of the classroom observations the educators were informed in advance that observations would continue until enough information had been collected regarding their classroom practices. Each educator was therefore observed for four periods of one hour each. To clarify certain issues, a brief discussion was held with each educator to determine the topic, the learning content to be covered, the assessment standards as well as the Learning Outcome to be achieved. The educators were also told that the researcher was only interested in observing the actual nature of their practices.

A Science Process Skill Observation Scale (see Appendix B) was used to measure the degree to which the use and development of science process skills were applied by the educators in their science lessons. The instrument evaluated the following descriptors regarding the implementation of the different science process skills:

1 observing and comparing

2 questioning

3 predicting

4 conducting investigations

5 recording results and

6 evaluating and communicating findings.

3.1 Descriptor 1: Observing and comparing

Descriptor 1 illustrates the degree to which the learners were given the opportunity to make observations and comparisons. Data from this observation revealed that three of the educators had given the learners the opportunity to observe and compare a phenomenon or substance. Amanda, the grade 4 educator, presented a lesson on the bean seed and as an introduction she asked the learners to observe and compare different kinds of seeds such as sunflower seeds, peas, beans and various fruit seeds. Thereafter the learners were asked to describe and compare each seed in terms of colour, size, texture, shape, hardness and odour. The learners were very enthusiastic and excited to participate since it was a simple activity. David, the grade 5 educator, presented a lesson about the expansion and contraction of gases and as introduction he performed an experiment in which the learners were asked to observe

and compare what happens to a copper coin when placed over the mouth of a bottle when it gains and loses heat energy. The learners were then requested to describe their observations verbally. Although the learners struggled to describe the events they observed, they appeared very eager to answer the questions posed by raising their hands frequently. Phumeza, the grade 7 educator, presented a lesson about measuring distances in which she asked the learners to look at different objects such as textbooks, their notebooks, the desk, the educator's table, a five-rand coin and a soccer ball, and asked them to compare each and describe the similarities and differences between them. Data from this observation revealed that learners participate more effectively when working with real objects. In contrast to the other three educators, Vuyokazi, the grade 6 educator, presented a lesson about electricity and data from this observation revealed that this particular educator did not provide the learners with opportunities of observing and comparing of substances. The educator introduced the researcher, outlined the purpose of the class visit, laid down a few ground rules and started the lesson with a few questions. Table 1 reflects how each educator was rated against the first descriptor of the Science Process Observation Skill Scale, namely observing and comparing:

Table 1

Skill Observation Scale: Observing and Comparing

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well	X	X		
Performed satisfactorily				X
Not seen			X	

3.2 Descriptor 2: Questioning

Descriptor 2 identifies the degree to which the educators asked investigable questions and this included the extent to which the learners were encouraged to raise questions which can be answered by scientific investigation as well as questions that arises from curiosity and the desire to understand. The importance of questioning is discussed in Chapter Two in the terms of Harlen (2000). Data from this observation revealed that the educators knowledge of the nature of investigable questions was at best limited as none of them asked anything remotely related to an investigable question. Learner independence was not promoted in asking investigable questions. Instead, the questions asked by each educator were direct, simple, to the point and mostly focussed on content and knowledge. The questions were closed questions and rarely inquiry-orientated. Table 2 illustrates how each educator was rated against the second descriptor of the Science process Observation Skill Scale, namely questioning:

Table 2

Skill Observation Scale: Questioning

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well				
Performed satisfactorily				
Not seen	X	X	X	X

3.3 Descriptor 3: Predictions

This third descriptor measured the degree to which the learners were given the opportunity to respond to ‘what if’ questions. Data from this observation revealed that three of the educators asked the learners to predict what would happen next in a given situation. Amanda, for example, asked the learners to predict what would happen to soaked bean seeds in cups covered with cotton wool when one sample is placed in a warm place with enough sunlight and another placed in a cold dark cupboard. Responses to this question varied, but the learners were very eager to make a prediction. Similarly, David asked his grade 5 learners to predict what would happen to a balloon pulled tightly over a narrow-necked bottle when the bottle is placed in a basin of hot water and also what would happen to the balloon if the bottle is placed in a basin filled with cold water. The learners were quick to answer and anxious to give the correct answer.

The grade 7 learners were requested by their science educator, Phumeza, to predict the distance around the objects in the paragraph mentioned in descriptor 1. Data from this descriptor (predictions) revealed that the educator focused too much on 'correct answers' instead of allowing the learners to practise this important skill and learn through mistakes. Since the educator focused on the correct answer the learners were also anxious to predict the correct answer. Pre-judging an outcome of any prediction according to Ward et al. (2008) is problematic because it promotes the idea that there is only one answer. The grade 6 educator, Vuyokazi, did not display any evidence related to descriptor 3, namely predictions. Table 3 illustrates how each educator was rated against the third descriptor of the Science Process Skill Observation Scale, namely predictions:

Table 3

Skill Observation Scale: Predictions

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well	X	X		
Performed satisfactorily				X
Not seen			X	

3.4 Descriptor 4: Conducting investigations and collecting data

This descriptor measured the degree to which the learners were given the autonomy to carry out instructions and procedures involving a small number of steps. Data from this

observation revealed that two educators displayed evidence of this approach to experimental procedure. A worksheet was handed to each learner in which the procedures of the investigation were outlined. Although the learners were actively involved in the lesson to a certain extent, data from this observation revealed that the educators controlled the class and the new learning content to be learned. The learners were rarely given the autonomy to manipulate the learning content on their own or to discover new content on their own. Instead, data collected from the experiments were orally explained and new terms were recorded on the board. The grade 6 and 7 educators gathered information through questioning. New learning content was explained in detail, and learner independence with respect to carrying out instructions and procedures was not observed. Table 4 reflects how the educators were rated against the fourth descriptor of the Science Process Skill Observation Scale, namely, conducting investigations and collecting data:

Table 4

Skill Observation Scale: Conducting Investigations and Collecting Data

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well				
Performed satisfactorily	X	X		
Not seen			X	X

3.5 Descriptor 5: Recording results

This descriptor involves the learners in recording information they have gathered from the investigation. Amanda's lessons were observed over a period of seven days. Her learners recorded their results on a daily basis by means of drawings, labelling and short descriptions et cetera. Amanda assisted the learners with certain terms relating to the development of the bean such as seed coat, embryo, cotyledons and radical. David's learners recorded their results on a worksheet after the experiment had been conducted. A word bank was provided to assist the learners to record the results since they struggled to draw conclusions based on the things they had seen. Vuyokazi recorded her notes about electricity on the board and the learners copied her notes, while Phumeza asked her learners to predict the distance around each object (textbook, notebook, the desk, educator's desk, five-rand coin and soccer ball) they had predicted. Thereafter, the learners were requested to measure the distance around each object with a ruler, record the distance of each object and finally calculate the difference between the predicted distance and actual distance of each object. The learners also completed an activity about the perimeter (the distance around a shape) of polygons in their workbooks. Table 5 shows how each educator was rated against the fifth descriptor of the Science Process Skill Observation Scale, namely recording results:

Table 5

Skill Observation Scale: Recording Results

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well				X
Performed satisfactorily	X	X		
Not seen			X	

3.6 Descriptor 6: Evaluating and communicating results

This descriptor illustrates the degree to which the learners were encouraged to reflect independently on the way the experiments had been conducted, the results obtained and if they should repeat the experiment, how these results could be improved. Data generated by observing what was happening in the four educators' classrooms in this study revealed that learner independence was not encouraged and the reviewing of procedures and experimental designs by learners did not take place. This lack of what might be considered an essential part of any investigation is not uncommon in the science education literature on investigations and inquiry-based learning and teaching (Dawson & Venville, 2007; Harlen, 2000; Ward et al., 2008). In this present study learners were never requested to report on their results, share the information they had gathered, report on patterns found or draw inferences. Instead, each educator gave a summary of the learning content. Thereafter, questions were asked to assess the learners' knowledge of the learning content. Table 6 illustrates how each educator was

rated against the sixth descriptor of the Science Process Skill Observation Scale, namely evaluating and communicating results:

Table 6

Skill Observation Scale: Evaluating and Communicating Results

Criterion	Educators			
	Amanda	David	Vuyokazi	Phumeza
Performed in an outstanding manner				
Performed well				
Performed satisfactorily				
Not seen	X	X	X	X

4. FOCUS-GROUP INTERVIEW

After the interviews and classroom observations, the participants were invited to participate in a group interview which lasted between 70 and 80 minutes, to obtain a deeper understanding and insight into the types of formal continuous assessment tasks,the educators used to assess a range of process skills. These tasks were introduced by the DoE in 2008 to give regular feedback through controlled tests, investigations, case studies, research projects and translational tasks (Provincial Assessment Guideline for Natural Sciences, 2007). Therefore, each educator should develop a year-long programme of assessment for each grade. Formal assessment is carried out to obtain reliable records that will enable the educator to determine the overall competence in the learning outcomes and assessment

standards. The recorded evidence is used to decide whether learners should progress or promoted to the next grade (Provincial Assessment Guideline for Natural Sciences, 2007).

The group interview was welcomed by the educators since they felt they remembered things they had not mentioned during the interviews. The group interview therefore focused on the following:

- The educators' understanding of the formal continuous assessment tasks (translational tasks, research projects, case studies and investigations)
- their current assessment practices; and
- suggestions as to what support could be given to educators to improve their assessment practices regarding the implementation of the common assessment tasks.

From the group interview it transpired that with the introduction of the formal continuous assessment tasks in February 2008, the four educators' understanding of some of these novel assessment tasks seemed to be limited. As a result of their lack of understanding of these new assessment tasks, such as authentic investigations, case studies, translational tasks and projects, the educators made an effort to read more about them so that they could at least comply with the DoE policy. They indicated that even though they had done some research about these novel tasks, they still felt unsure about their application and design. Amanda and Vuyokazi mentioned that they had tried to design a case study but did not know whether their attempt would be acceptable to other educators and whether they were doing the 'right' thing. Their lack of confidence is seen in their insecurity concerning the reliability and validity of their efforts.

The educators indicated that their current form of assessment practices consists mostly of tests and examinations. When asked why they rely mostly on tests and examinations, they commented that it is much easier to draw up a test since it is less time-consuming and learners are required to complete the question within a specified time. The educators also stated that although they were very insecure about authentic investigations, they try to assess the learners' competencies and knowledge via investigations since investigations are clearly embedded in Learning Outcome 1(LO 1), namely Scientific Investigations and therefore compelled to do "something about LO1."

Furthermore, the group was also concerned about uniformity regarding the content to be taught in Natural Sciences, and hence the assessment of this content, as most of the schools in their region (Nelson Mandela Metropolitan Municipality) taught different content. Educator uncertainty about the level at which a certain topic or concept should be taught was also highlighted.

The group suggested that educators should be trained and supported in a practical and realistic manner through demonstrations, as well as making learning material and resources available that would encourage them to design the required assessment tasks as outlined by the Provincial Assessment Guidelines (2007) for Natural Sciences.

From the focus-group interview it was deduced that the Department of Education depended too much on the educators' individual capacities with regard to the implementation of the different assessment tasks. Fullan (2007, p. 92) argues that governments cannot depend on individual educators' capacities to bring about substantial change: "the process has to be propelled with high quality teaching and training material."

5. SUMMARY AND CONCLUSION

From the empirical data gleaned from the interviews, observations and focus-group interview the following deductions can be made. Firstly, the implementation of science process skills was influenced by the educators' understanding of the concept or rather the lack thereof. It also transpired that what has been lacking to date is effective support being provided to educators grappling with the entire science curriculum owing the number of barriers as highlighted by them. Data generated from this study clearly suggest the need for clear directions, practical guidance and quality support to improve the teaching and learning of the science curriculum. In Chapter Five a general overview of the results of this study will be presented followed by recommendations that flow from these results,

CHAPTER FIVE

DISCUSSION OF RESULTS

1. INTRODUCTION

A discussion of the research results is presented in this section. Firstly, a general overview of the research results is discussed and presented, where after data generated from each educator are discussed separately. Following this discussion, information collected from the focus-group interviews and the learners' assessment activities are interpreted and outlined.

2. GENERAL OVERVIEW

The purpose of this study was to evaluate the implementation and development of science process skills in the teaching and learning of Natural Sciences for grades 4 - 7 learners. This was done via four educator case studies.

The first research sub-question was: *How is the concept of science process skills understood by grades 4 – 7 educators?* The answer to this question suggests that the educators' understanding of science process skills plays a pivotal role in its implementation in that "no matter how willing you are, if you do not understand what is required from you, you will struggle to make the changes intended by the curriculum developers" (Saunders & Nduna, 2006, p. 13). Data generated from this study suggest that the educators' understanding of the concept science process skills influenced their confidence and ability to teach science through methods of inquiry. This study, therefore, supports the findings of

researchers such as Webb and Glover (2004), Wenham (2005) and Wessels (1998) that the educators' understanding of any area of science influences their classroom practices.

Furthermore, it was evident from this study that both the beliefs held by each educator about their role and how the learners learn directly influenced their instructional decisions. Amanda and David, for example, believed that their learners learn best through a method of inquiry, and the results from this study reveal that these two educators attempted to employ such an approach but their attempts were thwarted by some of the impediments they highlighted in Chapter Four. Data generated from Amanda and David's classroom practices revealed that the majority of their lessons were to a certain extent of an inquiry nature since elements related to descriptors 1, 3, 4, and 5 (see Chapter Four) were always present during their teaching. Elements related to descriptor 2and 6 were not observed. Vuyokazi and Phumeza held predominantly traditional beliefs about their classroom practices. These views were clearly visible in their science practices. None of the descriptors noted in Chapter Four were visible during classroom observations of Vuyokazi. Instead the lessons which the educator presented were focused on mastery of content with little emphasis on the development of skills and the nurturing of inquiry attitudes. Although elements related to descriptors 1, 3, and 5 (see Chapter Four) were present in Phumeza's science lessons, it was observed that this educator focused too much on accurate descriptions and always expected the 'textbook' response to each of the questions she posed. Data generated from this educator's classroom practices revealed that she clearly presented lessons consistent with direct instruction. Although beliefs are persistent, (Roehrig et al., 2007), they can be changed through intensive professional development programmes. This was the case with Amanda and David whose beliefs about their practices have changed from a teacher-centred approach

to an approach that is more inquiry-orientated, possibly as a consequence of their in-service study at the local university.

The lack of appropriate learning material and resources, the lack of professional continuous development and resistance to change, coupled with a lack of confidence in their teaching ability may explain why Vuyokazi and Phumeza find it difficult to change their classroom practices.

From this study it also transpired that training programmes provided by the DoE did not have any lasting impact on the educators' science practices. Fullan and Hargreaves (as cited in Wessels, 1998) are of the opinion that educator development implies that the individual teacher will act in the classroom in a way which is different from the way they acted in the past, but verbal reflections by the educators revealed that this change had not occurred in their individual cases. Instead they were bombarded with cold facts and abstract knowledge. Vuyokazi commented that she struggled to associate with the Natural Sciences document owing to her lack of understanding of the terms used in it. This view is reinforced by Blignaut (2009, p. 15) who is of the firm opinion that "if educators do not feel a sense of identification with policy documents its goals may be undermined by its practitioners."

Additionally, data generated from the four educator assessment practices revealed that they assessed the learners in a traditional manner as illustrated by the predominance of tests and examinations. There was hardly any sign of other forms of assessment such as case studies, research projects, translational tasks and other forms of authentic investigations. The one case study observed from the activity books of Vuyokazi and Phumeza's learners was not an authentic case study in that the specified situation was not analysed. The investigations

observed from the assessment activity books could not be described as authentic investigations since the result was already known before the investigation was conducted.

3. CONCLUSION

Data generated from the four cases revealed a number of critical issues regarding the implementation of science process skills. Firstly, the different themes that emerged from this study such as the educators' understanding, their beliefs about teaching, lack of confidence, resistance, lack of science equipment and appropriate furniture, lack of collegiality and lack of ongoing professional support, were found to play a central role in the implementation of science process skills. From the study it was evident that the educators' understanding of the concept science process skills and their beliefs about teaching and learning were clearly driving factors in the implementation thereof. Another factor that is of great concern is the educators' lack of understanding of the formal continuous assessment tasks since these tasks determine whether a learner should be retained or should proceed to the next grade.

Therefore, this study suggests, on the basis of the data collected and analysed, high quality and continuous support with regard to the implementation of science process skills is crucial in order to enhance the educators' understanding of these important skills and concepts.

4. RECOMMENDATIONS

On the basis of the data collected and analysed, the educators suggested three main recommendations that they felt would promote a better understanding of process skills, and as such, increase the chances of the effective implementation of these skills into the Natural Sciences class.

4.1 Appropriate learning material and realistic support

The individual interviews, informal and focus-group interviews with the four educators clearly indicated the need for the design and development of learning materials consistent with methods of inquiry that will motivate and guide educators to introduce learning activities that will reinforce the use and development of science process skills in their science teaching practices. School visits conducted by the Natural Sciences facilitators (district officials) to date have been limited and focused only on curriculum structures and curriculum documents such as learning programmes, work schedules, lesson plans and assessment activities. It is recommended that these visits should not only be limited to the evaluation of curriculum documents but should also focus on intensive classroom visits so that educators are supported and guided in a realistic and practical manner (Govender, 2007).

4.2 Continuous professional development

This refers to the knowledge and skills educators acquire to improve their classroom practices and enhance their effectiveness as educators (Dreckmeyer, 1994). As noted earlier, development implies "change in practice" (Fullan, 2007, p. 30). Verbal reactions from the educators revealed that they were not supported by the DoE to act any differently in their classrooms or to change their practices so as to align their practice with inquiry-based learning as outlined by the NCS (2002). For this reason data generated from this study suggests the need for South African educators to be exposed to developmental programmes whereby inquiry teaching strategies are instilled and developed. Lawson (2010) suggests that these skills and knowledge could be attained by actively involving educators in investigating phenomena, addressing issues of scientific significance and interest of the educators,

introducing educators to scientific literature, media and technology built on the educators' current understanding, abilities and attitudes and lastly responsible bodies (DoE, SMTs) encouraging educator collaboration. Similarly, in order for educators to grow professionally and to transform their practices, Wessels (1998) is of the opinion that educators should be afforded the opportunity to participate in hands-on workshops in which they physically work with the learning material, workbooks, posters, apparatus and other stimulus material. According to Wessels (1998), educators gain content knowledge, a deeper understanding of concepts and are immersed in a constructivist philosophy, both explicitly and through workshop practice.

4.3 Professional learning communities

The notion of "professional learning communities", according to Blignaut (2005), is increasingly gaining recognition in the literature and it is widely accepted that where such communities exist, the prospects of successful implementation are dramatically increased. Blignaut (2005) maintains that issues such as educator conceptions and classroom practices would be fruitfully addressed on a continuous basis through communities of practice.

Getting educators to change is a difficult phenomenon, according to Webb and Glover (2004) since most of them particularly resist complex, conceptual, longitudinal changes as opposed to change in management routines or temporary changes. As a practitioner and in conversation with other educators, it transpired that many of them resist change if they are uncertain about its consequences. Communities of practice provide opportunities for educators to support one another morally and emotionally and to engage in dialogue to discuss the meaning of educational changes and how to deal with them successfully. When

educators feel that their peers experience the same concerns and fears that they are experiencing, they become less hesitant about changing their practices and are more willing to accept change. Fullan (2007) states that communities of practice may serve as a source in which educators discuss and share effective practices, identify barriers, focus collectively on student learning and share norms and values. These communities support learning conditions for motivating the disengaged educator, they build and manage knowledge and they create shared language and standards for practice and student outcome (Fullan, 2007).

This study has highlighted the successes and failures of four educators in their attempts to align their practice with the NCS. It opens the debate on the practical implications of introducing innovation (viz. science process skills) into practicing teachers' Natural Sciences classrooms. The potential exists to further extend this debate by more research into the causes and limitations that might prevent speedy action on the three recommendations of this study.

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APPENDICES

Appendix A: Identification and interaction between data collection sources

Interview

1) What is your understanding of the concept of science process skills?

2) To what extent do you employ these basic skills in your science classroom?

3) Do you experience any problems regarding the implementation of these skills?

4) How could science educators be supported to implement science process skills more effectively?

5) Could you describe your educational background and experiences concerning the teaching and learning of Natural Sciences?

Appendix B: Observation Scale for Science Process Skills

Science Process Skills: Observation Scale

To what extent did the teacher promote the use and development of science process skills? Place a "x" in the box indicating how often you observed each of the following:

	1	**2**	**3**	**4**
Did the teacher encourage the learners to use their senses (sight, touch, smell, taste, and listen) to collect data in a practical situation?				
Did the teacher encourage the learners to describe an event in general or to identify its similarities or differences?				
Did the teacher promote student independence in contributing an investigable question to develop their thinking?				
Did the teacher encourage the learners to ask an investigable question?				
Did the teacher encourage the learners to make any predictions to respond to "what if" questions?				
Did the teacher promote student independence to carry out instructions, follow procedures and collecting data?				
Did the teacher encourage the students to record the results that they obtained from the investigation?				
Did the teacher employ strategies to motivate the learners to reflect, or construct meaning to their ideas? To evaluate and communicate their findings?				

Score	**Criterion**
1	Not seen
2	Performed satisfactorily
3	Performed well
4	Performed in outstanding and advanced manner

Appendix C: Rating Scale for the Assessment Activity in Science Process Skills

Assessment Activity Science Process Skills Rating-Scale

To what extent did the students (learners) use science process skills when completing

Assessment activities? Circle the appropriate value for each item.

How well did the learners relate to observations and respond to the investigable questions?	1	2	3	4
How well did the learners respond to “what if” questions?	1	2	3	4
How well did the learners conduct scientific investigations and collect data?	1	2	3	4
How well did the learners record their data?	1	2	3	4
How well did the learners interpret the data, in other words putting the results together so that patterns can be seen?	1	2	3	4
How well did the learners express their thinking and explain the science in the process or word?	1	2	3	4

Rating:

1 means- having difficulty

2 means –fair

3 means good

4 means -outstanding