

# Development of Science Process Skills in the Teaching of Physical Science in Secondary Schools

by

Maumela Ntsundeni Eric

A mini dissertation

submitted to the School of Education  
in partial fulfillment of the requirements of  
Master of Science Education

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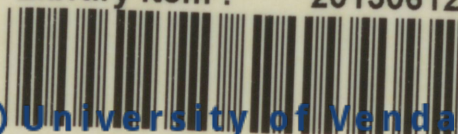
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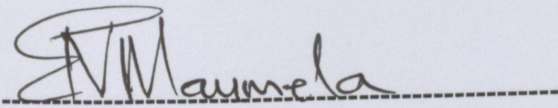


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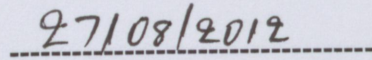
## DECLARATION

### DEDICATION

I **Ntsundeni Eric Maumela (Student No. 9100076)** hereby declare that the work reported in this dissertation is my original work and has not been submitted for a similar degree in any other University. Sources cited have been listed in the references section.



**Maumela Ntsundeni Eric**



**Date**

## ACKNOWLEDGEMENTS

### DEDICATION

I dedicate this mini dissertation to my wife Doris, daughter Rinae, son Rifarise, my mother Annah Maumela and my mother-in-law Tshavhungwe Makungo.

My constructive criticism, genuine guidance, support, and encouragement throughout the entire study made this journey a success. Mr. S. Robert also played an important role. I would like to thank him for his assistance and guidance in data analysis. He opened my eyes to many ways and his inputs in this study were valuable.

I would like to thank Professor Arrey, Mafua Pema, and Simiso David for their expertise and support throughout this study. Without their guidance and encouragement, this study would not have been finished. I would also like to thank the educators and learners who allowed me into their classrooms and participated enthusiastically in the study.

I also want to thank Circuit Managers, Principals and Science Teachers at Vhembe District who allowed me to carry out the study and also participated in this study. All of them made the last moments to visit the different schools and conduct my research.

Finally, I am indebted to my wife Doris, daughter Rinae, son Rifarise, my mother Annah Maumela and my mother-in-law Tshavhungwe Makungo, who portrayed high levels of tolerance and understanding despite being lonely at home. Their support and kindness were the key to my success.

Lastly, thank you to God who gave me good health throughout the study. His mercy and grace are beyond measure.

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### ABSTRACT

I sincerely wish to express and appreciate the role played by my supervisor, Dr H.N. Mutshaeni, who is a Senior lecturer at the University of Venda. Her constructive criticism, positive guidance, support, and encouragement throughout the entire study made this study a success. Mr S. Kaheru also played an important role. I would like to thank him for his assistance and guidance in data analysis. He opened my eyes in many ways and his inputs in this study were valuable.

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Physical Science, as a subject, has an important component called the learning of Science Process skills. Science Process Skills are very important and need to be developed among learners. These are skills which are still not very well-developed among the majority of teachers. This study sought to evaluate the state of development of these skills in the teaching of Physical Science in Secondary Schools. Physical Science educators were randomly selected to participate in this study. They completed questionnaires based on the study. Quantitative data were only gathered since the study was mainly quantitative. Data generated from this study were carefully analysed and on the basis of their interpretation, it was concluded that the majority of teachers are developing basic and integrated Science Process skills in the teaching of Physical Science lessons. Science process is not just useful in science but in any situation that requires critical thinking.

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## CHAPTER 1

### ORIENTATION TO THE STUDY

#### 1.1 BACKGROUND/INTRODUCTION

Science scholars agree that Science is more than a body of knowledge and a way of accumulating and validating that knowledge. It is also a social activity that incorporates certain human values and principles. Science must be exercised as a phenomenon of new knowledge and application; it should not be influenced by personal agendas or dogma.

With the introduction of the National Curriculum Statement (Harlen, 2009) 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 National Curriculum Statement. 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 that learners are engaging in observing and comparing phenomena, as well as asking questions to be investigated, making predictions, conducting investigations, collecting data, recording results and, lastly, evaluating and communicating their findings (Harlen, 2009).

Many studies conducted with middle and high school students found that science process skills had positive effects on students' achievements, cognitive development, laboratory skills, and on their understanding of Science knowledge as a whole. This was not the case with students taught using the traditional approach (Gibson & Chase, 2002). Developing these skills does not happen of its own accord; teachers have to acquire them (Van Huyssteen, 1981). Developing these skills and being able to use them comes with practice (Harlen, 2000).

In teaching science, students need time to explore, make observations, take wrong turns, do things over again, build things, calibrate instruments, collect things, construct physical and mathematical models for testing and learn mathematics, technology and science. They may need to deal with questions at hand, ask around, read and argue, wrestle with unfamiliar and counter intuitive ideas and also to see the advantage of thinking in different ways.

The third dimension of science focuses on the characteristics, attitudes and Process skills in science are very important in the formal presentation of science to learners. There is a strong belief that learners who are properly introduced to science through process skills will find the skills useful throughout life. While it is possible to easily forget science content, process skills tend to remain with many individuals for a relatively longer period.

According to the National Science Teacher Association, it follows that a reasonable portion of the science curriculum should emphasise science process skills. In general, research literature indicates that when science process skills are specific planned outcomes of a science programme, those skills can be learned by student.

Given the situation as introduced above, this study attempts to determine the extent to which basic and integrated process skills are developed and applied during physical science lessons in the secondary schools.

## 1.2 STATEMENT OF THE PROBLEM

The study seeks to investigate the extent to which basic and integrated process skills are developed and applied during physical science lessons in the secondary schools. Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are important. The first of these includes the content of science, the basic concepts, and our scientific knowledge. This is the dimension of science that most people first think about, and it is certainly very important.

The other two important dimensions of science are processes of doing science and scientific attitudes. The processes of doing science involve the science process skills

that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that we all use in our daily lives as we try to figure out everyday questions. When students are taught to use these skills in science, they are also taught the skills that they will use in the future in every area of their lives.

The third dimension of science focuses on the characteristics, attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is a respect for the methods and values of science. These scientific methods and values include seeking to answer questions using some kind of evidence, recognising the importance of re-checking data, and understanding that scientific knowledge and theories change over time as more information is gathered.

Therefore, the study seeks to investigate the extent to which basic and integrated process skills are developed and applied during physical science lessons in secondary schools

### 1.3 PURPOSE OF THE STUDY

The purpose of this research study is to investigate the extent to which basic and integrated process skills are developed and applied during physical science lessons in secondary schools.

### 1.4 OBJECTIVES OF THE STUDY

By the end of this research study, the researcher will be able to:

- Describe the Physical Science Educator's perceptions of the development and application of basic and integrated process skills during physical science lessons; and
- Investigate the extent to which the basic and integrated process skills are developed among learners in secondary schools.

## 1.5 RESEARCH QUESTIONS

The study sets out to address the following research questions:

- What do science educators perceive as basic and integrated process skills?
- How do science educators develop basic and integrated skills during their physical science lessons?
- To what extent are the basic and integrated process skills developed among learners in secondary schools?

## 1.6 ASSUMPTIONS

The assumptions specified are as follows:

- Science process skills are not fully applied by teachers during Physical Science lessons.
- The development of science process skills of learners is not satisfactory.
- The science inquiry method is not fully applied in teaching and learning classes.

## 1.7 RESEARCH DESIGN AND METHODOLOGY

Permission to conduct research was sought from the District Senior Manager and a research design is a plan or blueprint of how one intends to conduct 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 developed and applied in the teaching and learning of Natural Sciences for grades 10 -12 learners at secondary schools. A case study design was used to gather relevant and appropriate information about the educators' classroom practices with respect to the development and application of science process skills.

### 1.7.1 Population

Population is the entire group of items or individuals from which the samples under consideration are presumed to come. Melvin and Goddard (1996:29) state that a

population is any group that is the subject of research. Population is sometimes referred to as the universe. It is defined as the entire group whose characteristics are to be estimated (Ndagi, 1984:75).

The population of this study is comprises of all Physical Science educators from Vhembe District.

### 1.7.2 Sample

Thirty educators participated in this study. 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 in the same locality. These educators were selected on the basis of their willingness to participate in the study, as well as the fact that these educators are teaching physical science earlier you wrote this with Grade 10, 11 and 12 learners.

## 1.8 DATA COLLECTION PROCEDURE

Permission to conduct research was sought from the District Senior Manager and principals of schools. A self-designed questionnaire was distributed to the respondents for completion. A date was set for the collection of completed questionnaires.

## 1.9 DATA ANALYSIS

This can be regarded as the presentation of data collected in a more accurate and credible manner. Data is put together in a chronological order (Rubin & Rubin, 2005: 230).

For the purpose of this study, data collected by means of self-administered questionnaires was analysed using a computer package, the SPSS version 19. Through use of this package, variety of numeric data and statistical techniques were used.

## **1.10 DELIMITATIONS AND LIMITATIONS**

### **1.10.1 Delimitations**

The scope of this study is limited geographically to secondary schools in Vhembe District which are located in close proximity to the secondary school at which the researcher teaches. In the randomly selected schools, only randomly selected Grade 12 Physical Science educators and their learners will be studied.

### **1.10.2 Limitations**

The two limitations of this study were time and money. The researcher is a full time educator in a secondary school and therefore has limited time to go and collect research data from other schools. Hence, time limited the scope of the study. Financial constraints limited this study, since it is not funded. This factor sets limits on both the travel to and from other schools, the duplication, and administration costs of research instruments.

## **1.11 ETHICAL CONSIDERATIONS**

The research participants were assured of anonymity. The participants were informed about the objectives of the study before the test was administered to them. All the procedures that involved the participants were explained to them and they told that it was their right not to participate if they were not interested. Research participants were also assured that their scripts would be handled by the researcher and his supervisors only.

## **1.12 SIGNIFICANCE OF THE STUDY**

The significance of this study lies in the fact that learners who have developed both basic and integrated process skills will apply them during subsequent science lessons. This will not only make their science lessons more meaningful, but it will also enhance their field investigation skills.

Learners will develop both basic and integrated skills and they will be actively engaged with the science knowledge they are learning. The study is also significant for the science educators in that they will find it relatively easy to engage learners using the inquiry teaching approach. After they have developed basic and integrated process skills, they will apply them to solve everyday problems.

Effort, time and energy are being spent in carrying out this study because science is both content and process. If educators concentrate on content, the process skills will not be developed in the learners. But it is the application of these basic and integrated process skills that leads to discoveries and the construction of the science knowledge.

That inquiry and research skills will not happen without basic and integrated process skills, make it imperative that these processes must be develop in both girls and boys.

### 1.13 OUTLINE OF THE STUDY

This study consists of five chapters. The contents of the chapters is 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 literature on science process skills, the nature of science, integrated and basic process skills.

**Chapter Three** describes the methodology used in this study to collect data as well as the research design.

**Chapter Four** presents the findings and discusses the results obtained from the interviews, observations, focus-group interviews, teacher assessment activities as well as their implications.

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

## LITERATURE REVIEW

### 2.1 INTRODUCTION

The term "process skills" refers to the learners' cognitive activities 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:

#### 2.1.1 Observing and Comparing

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

#### 2.1.2 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 (NCS, 2002).

#### 2.1.3 Predicting

This involves the learners 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 making predictions from patterns in information.

## LITERATURE REVIEW

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This involves the learners 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 making predictions from patterns in information.

## 2.1.4 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. He/she follows a simple worksheet to set up equipment to obtain information and collect data, as the investigation purpose requires (NCS, 2002).

## 2.1.5 Recording Results

This process skill may involve learners recording using a form which is prescribed (for example; sentences, lists, tables, labelled diagrams). It may involve selecting a suitable form to record information when asked to do so, knowing when it is important to record, and doing so without being prompted by the educator.

## 2.1.6 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.

Process skills in science for learners emphasise the use of our five sense organs. Although there are more than five basic process skills in science, namely, observing, classifying, measuring, communicating and reading, these are considered starting points. The scientific method, scientific thinking and critical thinking have terms used at various times to describe these skills.

The term "science process skills" is commonly used and has been popularised by the curriculum project, Science – A Process Approach (SAPA). These skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behaviour of scientists. SAPA grouped process skills into two types, namely; basic and integrated. The basic (simpler) process skills provide a foundation for learning the integrated (more complex) process skills. These skills are listed and described below:

## 2.2 BASIC SCIENCE PROCESS SKILLS

Basic process skills represent the foundation of scientific reasoning that learners are required to master before acquiring and mastering the advanced integrated science process skills (Brotherton & Preece, 1995:5). These skills can be described as follows:

- Observing - uses the senses to gather information about an object or event. For example, describing a pencil as yellow.
- Inferring - Making an “educated guess,” an object or event based on previously gathered data of information. For example, saying that the person who used the pencil made a lot of mistakes because the eraser was well worn.
- Measuring – Using both standard and non-standard measures and events. For example, using a meter stick to measure the length of a table in centimetres.
- Communicating – Using words or graphic symbols to describe an action, object or event. For example, describing the change in height of a plant over time in writing or through a graph.
- Classifying – Grouping or ordering objects or events into categories using established properties or criteria. For example, placing all rocks having a certain size or hardness into one group.

Predicting stating outcomes of a future event based on a pattern or evidence. For example, predicting what the height of a plant would be in two weeks based on information of its growth during the previous four weeks, which is presented graphically.

Children who can perform these skills are likely to show understanding of basic science processes (Martin, 1994:11) and perform integrated science process skills.

## 2.3 INTEGRATED SCIENCE PROCESS SKILLS

Integrated process skills include skills such as identifying variables, constructing tables of data and graphs, describing relationships between variables, acquiring and

processing data, analysing investigations, constructing hypotheses, operationally defining variables, designing investigations and experimenting (Funk, 1979:83). These skills can be described as follows:

- Controlling variables – Being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating the independent variable only. For example, realising through past experiences that the amount of light water need to be controlled when testing to see how the addition of organic matter the growth of beans.
- Defining operationally – Stating how to measure a variable in an experiment. For example, stating that bean growth will be measured in centimetres per week.
- Formulating hypotheses- Stating the expected outcome of an experiment. For example, the greater amount of organic matter added to the soil, the greater the bean growth.
- Interpreting data- Organizing data and drawing conclusions from it. For example, recording from an experiment on bean growth in the form of a data table and forming a conclusion which relates trends in the data to variables.
- Experimenting – Being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a “fair” experiment, conducting the experiment and interpreting the results of the experiment. For example, the entire process of conducting the experiment of the effect of organic matter on the growth of bean plants.
- Formulating models – Creating a mental or physical model of the process or event. For example, the model of the processes of evaporation and condensation interrelate in the water cycle.

Brotherton and Preece (1995:5) argue that scientists are only able to use integrated skills effectively once they have mastered the basic skills.

The science process skills form the foundation for scientific methods. There are six basic science process skills, namely,

- Observation,
- Communication,
- Classification,

## 2.4 TEACHING BASIC PROCESS SKILLS

• Inference, and

Numerous research projects have focused on the teaching and acquisition of basic process skills. For example, Padilla, Cronin and Twist (1985) surveyed the basic process skills of 700 middle school students with no special skill training. They found that only 10% of the learners scored above 90%, even at the grade level. Several studies have found that teaching increases the levels of skills performance. Thiel and George (1976) investigated predicting among third-fifth graders while Tomer (1974) observed among seventh grades. These studies showed that basic skills can be taught and that when learned, they can be readily transferred to new situations. These studies also showed that teaching strategies which seemed effective were:

- Applying a set of specific clues for predicting;
- Using activities and pencil and paper simultaneously to teach graphs; and
- Using a combination of explaining, practice with objects, discussions and feedback, together with observation. This is observing. In other words, just what research and theory have always defined as good teaching.

Studies focusing on the Science Curriculum Improvement Study (SCIS) and SAPA indicate that elementary school students, if taught process skills abilities, not only learn to use those processes, but also retain them for future use. Researchers, after comparing SAPA learners to those experiencing a more traditional science programme, concluded that the success of SAPA lies in the area of improving process-oriented skills (Widen, 1975). Thus, it seems reasonable to conclude that learners learn basic skills better if they are considered an important object of instruction and if proven teaching methods are used.

The science process skills form the foundation for scientific methods. There are six basic science process skills, namely;

- Observation;
- Communication;
- Classification;

- Measurement;
- Inference; and
- Prediction.

## 2.5 THE NATIONAL CURRICULUM STATEMENT (NCS) FOR NATURAL

These basic skills are integrated when scientists design and carry out experiments or in everyday life when we all carry out fair test experiments. All six basic skills are important individually as well as when they are integrated. The six basic skills can be put in a logical order of increasing sophistication, although even the youngest students will use all of the skills alongside one another at various times in their learning.

### 2.5 TEACHING INTEGRATED PROCESS SKILLS

Several studies have investigated the teaching of integrated science process skills. Allen (1973) found that third graders can identify variables if the context is simple enough. Both Quinn and George (1975) and Wright (1981) found that learners can be taught to formulate hypothesis and that this ability is retained overtime.

Others have tried to teach all of the skills involved in conducting an experiment. Padilla, Okey and Garrand (1984) systematically integrated experimenting lessons into the middle school science curriculum. One group of learners was taught a two week introductory unit on experimenting which focuses on manipulative activities. A second group was also taught the same experimenting unit, but above all this, experienced one additional process skills activity per week for a period of fourteen weeks. These results indicated that the more complex process skills cannot be learned via a two week unit which with science content is typically taught. Instead these skills need to be practiced over a longer period of time.

Process skills, sometimes referred to as scientific processes, are tools which most rational human beings use. With this tool, problems are unravelled and solutions found. Process skills should be understood as a useful guide plan. There are still debates on whether process skills follow the sequence in which they are presented. Science begins when an observation is made about a phenomenon. Many

educators therefore advise that observation should be the starting point of science. There after, the other skills are used as the need arises.

## 2.6 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, emphasise science learning for all learners in South Africa and a paradigm shift from the traditional approach of teaching science, namely, an approach that places greater focus on the mastery of content, that is 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).

This new approach to science education in South Africa 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. These should 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 development of science process skills and inquiry-based learning is 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 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 emphasise 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, which would in turn lead them to developing a hypothesis, which might explain the phenomena. Learners would then plan and carry out an investigation; they would

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 realised. 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

## 2.7 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 (cited in Wessels, 1998:11), who states 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 schools. 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, 2002:4). 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, and Dreckmeyer (1994). Harlen (2000:7) for example, defines 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.

## 2.8 THE EDUCATORS' UNDERSTANDING OF SCIENCE PROCESS SKILLS

There are at least three major domains of the educators' professional knowledge; namely;

- 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. This is because educators with a particular understanding of these skills, for example, will consciously or unconsciously shape their 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 perceptions.

In support of Wenham's (2005) arguments, Wessels (1998) argues 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, 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 *et al* (cited in Lotter *et al.*, 2007) have shown how educator beliefs of science instruction, science knowledge, and science learning influence the educator's 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).

## 2.9 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, this refers to learning strategies used in the process of understanding a new situation or in the presentation of it. It is through these skills that scientists collect data, put experiments together, analyse data and formulate results. Using these fundamental skills is 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 gain the ability to identify and use relevant scientific evidence to solve problems and make decisions (Harlen, 2000).

Research, including the NSES (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. 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 once students have been taught these skills, they are broadly transferable from one situation to another. They are also appropriate for many science disciplines and accurately reflect the skills used by scientists. Herman (2009) believes that globalisation, rapid change, the explosion and specialisation 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. Learners are expected to use these skills to create meaning and structure using the new knowledge they have gathered.

## 2.10 CONCLUSION

This chapter reviewed related literature. The next chapter outlines research design and methodology used in this study.

## CHAPTER THREE

### RESEARCH DESIGN AND METHODOLOGY

#### 3.1 INTRODUCTION

This chapter presents the methodology employed to gather data for this study. This includes a brief description of quantitative research methods. In addition, the methods and procedures used to collect data, 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.

#### 3.2 RESEARCH DESIGN

Kothari (2004) notes that a research design is the arrangement of conditions for collecting and analysing data in a manner that aims to combine relevance to the research purpose with economy in procedure. Gray (2009) maintains that a research design is the overlapping plan for the collection, measurement and analysis of data. A research design will describe the purpose of the study and the kinds of questions being asked, the techniques to be used for collecting data, approaches to selecting samples and how data are going to be analysed (Gray, 2009).

Bless, Higson-Smith and Kagee (2006) add that a research design relates directly to the testing of hypothesis. It is a specification of the most adequate operations to be performed, in order to test specific hypothesis under given conditions (Bless, Higson-Smith and Kagee, 2006). Mouton, 2001 defines a research design as a plan or blueprint of how one intends to conduct the research.

The purpose of this study is to investigate the extent to which science process skills are being developed and applied in the teaching and learning of Natural Sciences for Grades 10 -12 learners at secondary schools. A case study design was used to gather relevant and appropriate information about the educators' classroom practices. Focus was on the development and application of the science process skills.

### **3.3 RESEARCH METHODOLOGY**

Henning (2004) argues that “research methodology” refers to the coherent group of methods which compliment one another and which have the “goodness” to deliver data and findings that will reflect the research question and suit the research purpose (Henning, 2004). Furthermore, Welman, Kruger and Mitchell (2005) argue that “research methodology” considers and explains the logic behind research methods and techniques (Welman, Kruger & Mitchell, 2005). In this study, I utilised the quantitative approach.

### **3.4 POPULATION**

Population is the entire group of items or individuals from which the samples under consideration are presumed to come. Melvin and Goddard (1996:29) state that a population is any group that is subject of research interest. Population is sometimes referred to as the universe and it is defined as the entire group whose characteristics are to be estimated (Ndagi, 1984:75). In this study, the population consisted of all Physical Science teachers in Vhembe District.

### **3.5 SAMPLING**

Thirty educators participated in this study. 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 locality. These educators were selected mainly because of their willingness to be interviewed and observed as well as the fact that these educators are teaching Physical Science in Grade 10, 11 and 12.

### **3.6 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 researchers

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 and questionnaires.

### 3.6.1 Questionnaires

Questionnaires were developed and distributed to educators who taught science in secondary schools. These were designed to develop a greater understanding of the educators' understanding of science process skills, their current practices with respect to the development and application of these basic skills, their perceived impediments to implementation, as well as the support educators need to improve their practices with in the teaching of these basic science process skills. The questionnaire was distributed to 30 educators.

## 3.7 DATA ANALYSIS

In this study, the SPSS package version 19 was used to analyse the results. Data was analysed by means of frequencies, frequency tables and cross tabulations. The statistician with the help of a data analysis expert took considerable care to enter data from the study.

## 3.8 ETHICAL MEASURES

In the context of education, ethics are particularly important (McMillan & Schumacher 1993:197). They deal with beliefs about what is right or wrong, proper or improper, good or bad.

The researcher undertook to focus on the research questions and not to interfere in any manner that could jeopardise the integrity of data and the study as a whole. Respondents were assured that there would be no unpleasant or damaging effects on them or the school. Prior to the commencement of data collection activities, the researcher undertook to communicate the aim, objectives, nature and future use of findings to participants.

## CHAPTER 4

Permission to administer the questionnaire was obtained from the Department of Education in Vhembe District, Limpopo Province. Care was taken to follow ethical principles as recommended by Cohen *et al.* (2000:58). All the teachers who formed part of the sample completed and signed the informed consent form (see Appendix A).

This chapter presents on the quantitative data gathered from thirty educators who teach Physical Science from Grade 10 to 12. These teachers were randomly selected. The questionnaires were delivered to the target schools by the researcher after first obtaining permission from the principals. The questionnaires were handed to the principals who were requested to hand them to their Grade 10, 11 and 12 teachers. To avoid putting the teachers under too much pressure, the researcher gave them one week to complete the questionnaires in their own time. Questionnaires were then collected by the researcher from the principals.

The questionnaires were administered virtually anonymously, with the researcher only interacting only with the school principals. In these interactions, it was necessary to put respondents at their ease. This was done in a standardised way. At no point were the researcher's expectations discussed with the principals. Only the methodology was discussed.

### 3.9 CONCLUSION

In this chapter, the research design was discussed. The statistical techniques that were used in this research study were also identified.

The next chapter presents the findings of the empirical investigation.

## CHAPTER 4

### DATA ANALYSIS AND DISCUSSION

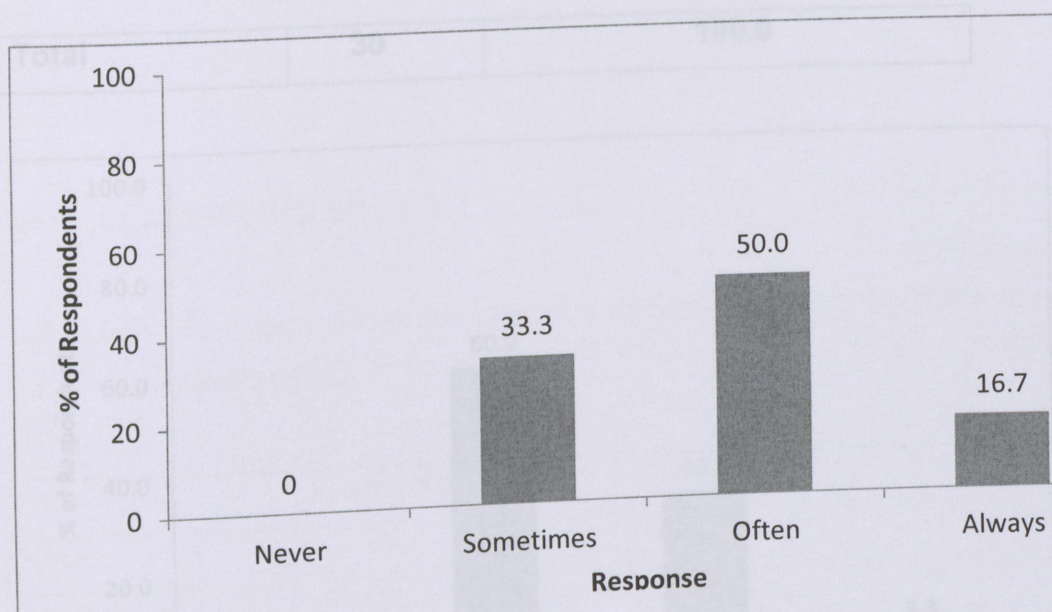
#### 4.1 INTRODUCTION

This chapter presents on the quantitative data gathered from thirty educators who teach Physical Science from Grade 10 to 12. These teachers were randomly selected from different schools. Quantitative data were collected using a questionnaire designed to measure the development of science process skills applied in their Physical Science lessons. The quantitative data were analysed through the computation of participant frequencies that illustrated the number of tallies, or the number of times an event happened in the classroom. This discussion was also elaborated in Appendix A, B and C.

#### 4.2 OBSERVATION SKILLS

**Table 4.1 I let my learners observe objects events in a variety of ways using one or more of their senses.**

	Frequency	Percent
Never	0	0
Sometimes	10	33.3
Often	15	50.0
Always	5	16.7
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.1: I let learners observe objects events in a variety of ways using one or more of their senses**

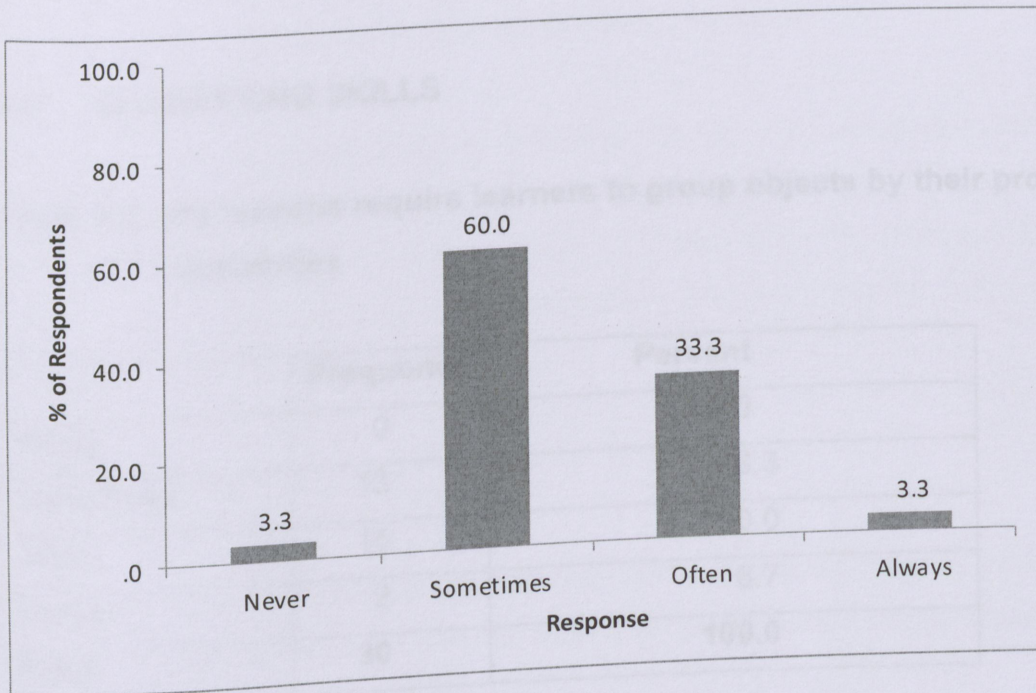
The findings revealed that 66,7% of teachers apply the observation skills in their teaching lesson or during practical work. Observation is the most basic and fundamental of the process skills. National Curriculum Statement of 2005 also emphasize the aspect of science process skills as the key deliverable aspect for teaching and learning Physical Science. One cannot compare, classify or perform the other process skills without being a good observer. Observation is the foundation of science process skills.

### 4.3 OBSERVING AND COORDINATING

**Table 4.2: I let my learners use indirect methods and devices such as hand lamps, microscopes and thermometer to observe events and objects**

	Frequency	Percent
Never	1	3.3
Sometimes	18	60.0
Often	10	33.3
Always	1	3.3

Total	30	100.0
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**Figure 4.2: I let my learners use indirect methods and devices such as hand lamps, microscopes and thermometer to observe events and objects**

The process of observing can be:

- Qualitative: This is identifying and naming the properties of an object such as its shape, colour, size, texture, smell and sound.
- Quantitative: This kind of observation involves measurement.
- Change: This could be the result of crushing, pounding, burning, cutting, decaying and others.

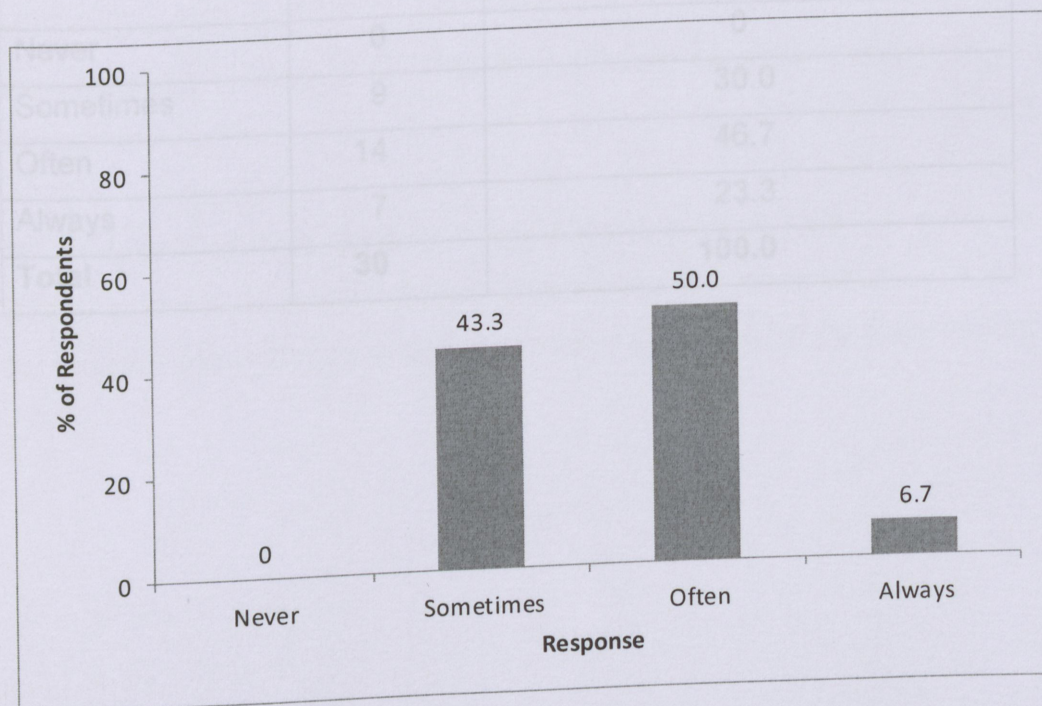
The observation skill can be diversified in many ways. The findings revealed that 33% of teachers should view this skill as the most fundamental skill for effective science teaching.

The findings revealed that 66,7% of the teachers are able to demonstrate the importance of classifying skills in their teaching activities. The findings show that 43,3% of the teachers sometimes apply classifying skills.

#### 4.4 CLASSIFYING SKILLS

**Table 4.3: My lessons require learners to group objects by their properties or similarities**

	Frequency	Percent
Never	0	0
Sometimes	13	43.3
Often	15	50.0
Always	2	6.7
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.3: My lessons require learners to group objects by their properties or similarities**

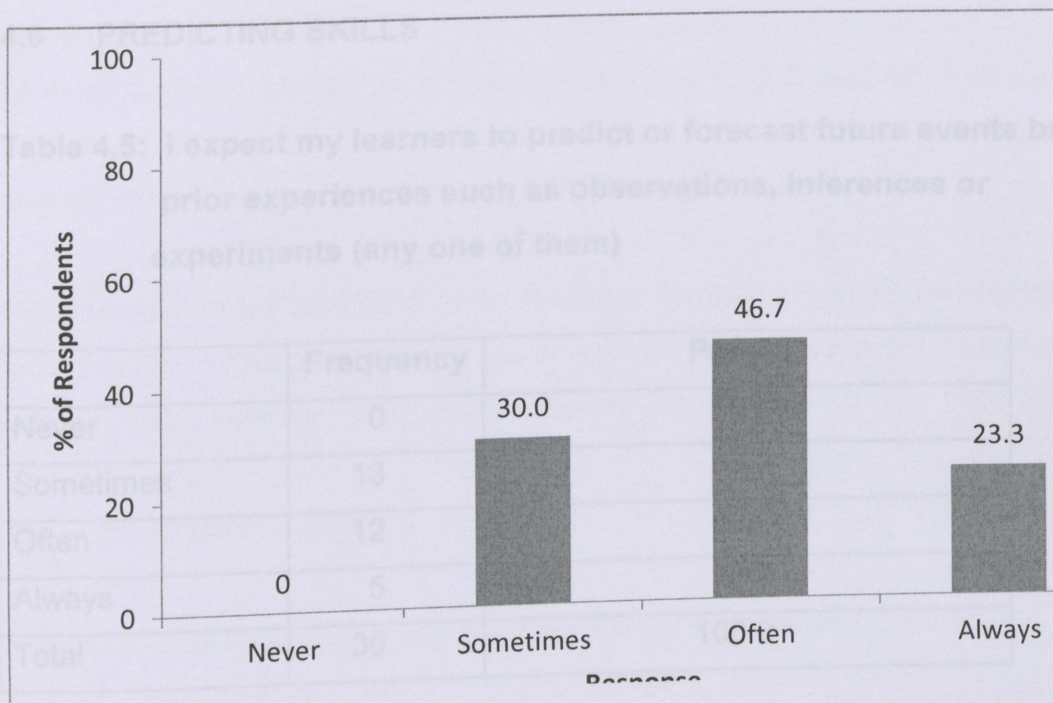
The findings revealed that 66,7% of the teachers are able to demonstrate the importance of classifying skills in their teaching activities. The findings show that 43,3% of the teachers sometimes apply classifying skills.

Classifying involves grouping or ordering events into categories based on their properties or criteria. There is an overwhelming number of things around us, for example, non-living and living things. Order can be attained by observing similarities, differences and interrelationships and by grouping them to suit some purpose.

#### 4.5 INFERRING SKILLS

**Table 4.4: I use activities in my lessons that require learners to infer explanations for events based on observations (hypothesis)**

	Frequency	Percent
Never	0	0
Sometimes	9	30.0
Often	14	46.7
Always	7	23.3
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.4: I use activities in my lessons that require learners to infer explanations for events based on observations (hypothesis)**

It is pleasing to note that 70% of the teachers show interest in developing the inference skills.

Observation involves getting information by using one or more senses, while inferring involves explaining or interpreting an observation. Inferring involves formulating assumptions or possible explanations based on observation.

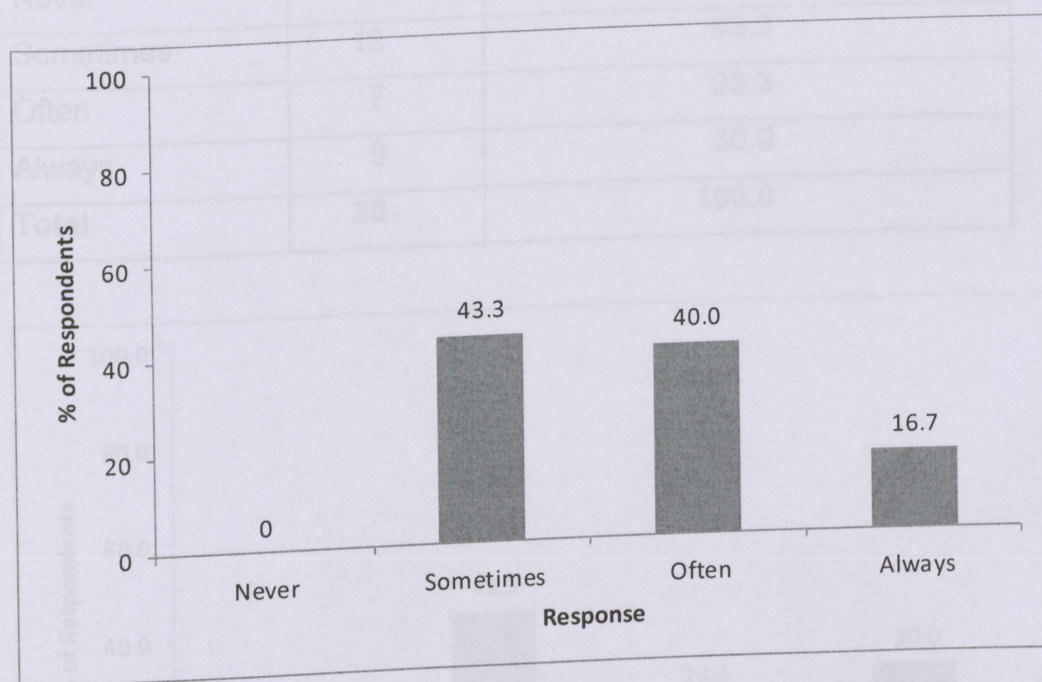
**Figure 4.5: I expect my learners to predict or forecast a future events based on prior experiences such as observations, inferences or experiments (any one of them)**

Prediction is the process of using past observations or data along with other kinds of scientific knowledge to forecast events or relationships. A statement not based on

#### 4.6 PREDICTING SKILLS

**Table 4.5: I expect my learners to predict or forecast future events based on prior experiences such as observations, inferences or experiments (any one of them)**

	Frequency	Percent
Never	0	0
Sometimes	13	43.3
Often	12	40.0
Always	5	16.7
Total	30	100.0



**Figure 4.5: I expect my learners to predict or forecast a future events based on prior experiences such as observations, inferences or experiments (any one of them)**

Prediction is the process of using past observations or data along with other kinds of scientific knowledge to forecast events or relationships. A statement not based on

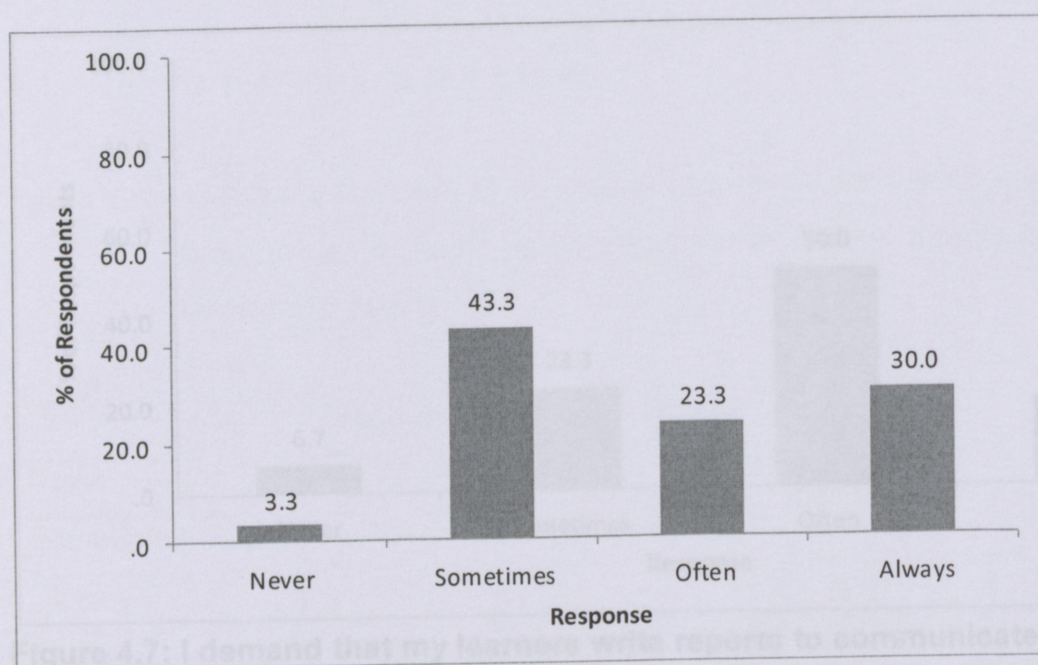
observations is not a prediction; it is simply a guess. Predication can be interpolation or extrapolation. Interpolation is predicting new data based on and within a trend, pattern of previously observed data, whereas extrapolation is predicting new data outside or beyond the range of previously observed data.

The findings show that 43,3% of the teachers sometimes apply the prediction skills in their teaching strategies. It is a useful skill for the development of science process skills amongst learners, but less affordable by teachers.

#### 4.7 MEASURING SKILLS

**Table 4.6: I teach my learners to measure accurately using length**

	Frequency	Percent
Never	1	3.3
Sometimes	13	43.3
Often	7	23.3
Always	9	30.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



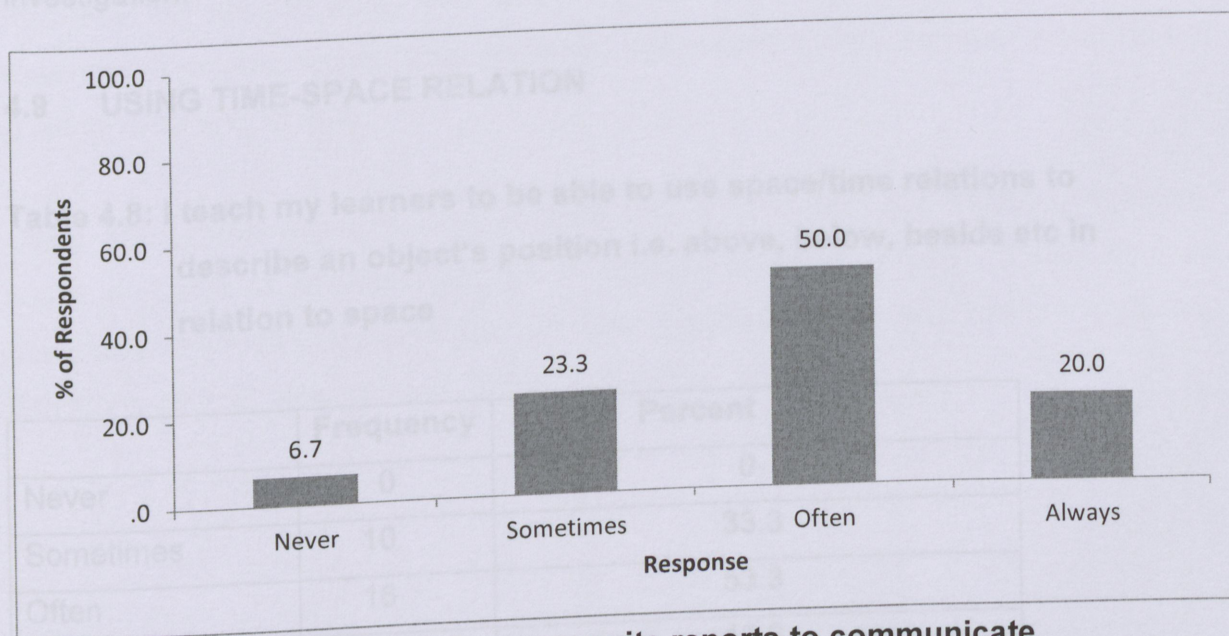
**Figure 4.6: I teach my learners to measure accurately using length**

The findings revealed that 66,6% of the teachers are in the process of developing these skills amongst learners. It is also pleasing to note that 30% of the teachers are always instilling these skills in their learners. Measuring are making quantitative observations. Measuring skills is applied to describe specific dimensions of an object or event. This information is considered quantitative data. the findings also show that 3,3% of the teachers do not apply measuring skills in their lessons. Measuring cannot be overemphasised in teaching and learning Physical Science. It is also a core skill for all science fields of study.

#### 4.8 COMMUNICATING SKILLS

**Table 4.7: I demand that my learners write reports to communicate knowledge gained from discussions and or observations**

	Frequency	Percent
Never	2	6.7
Sometimes	7	23.3
Often	15	50.0
Always	6	20.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.7: I demand that my learners write reports to communicate knowledge gained from discussions and or observations**

Communicating involves expressing ideas orally, in writing or with graphs, diagrams, tables or photographs. It is pleasing to note that 70% of the teachers recognise the importance of developing communication skills.

Involvement in activity-based science programmes provides learners with a multitude of experiences to draw from when they are thinking and writing (Simon & Zimmerman, 1980).

A study of the relationship between creative writing and science experiences indicates that when children write their own reading materials, their writing scores improve significantly (Jenkins, 1981).

Working with children from inner-city schools found significant gains in children's oral communication skills when they participated in Science Curriculum Improvement Study and Science - A Process Approach activities. Children who were exposed to Science - A Process Approach out-performed students who were not in tests of language output, vocabulary, sentence structure, and classifying, transmitting and receiving and oral communication skills (Bethel, 1974; Huff & Languis, 1973).

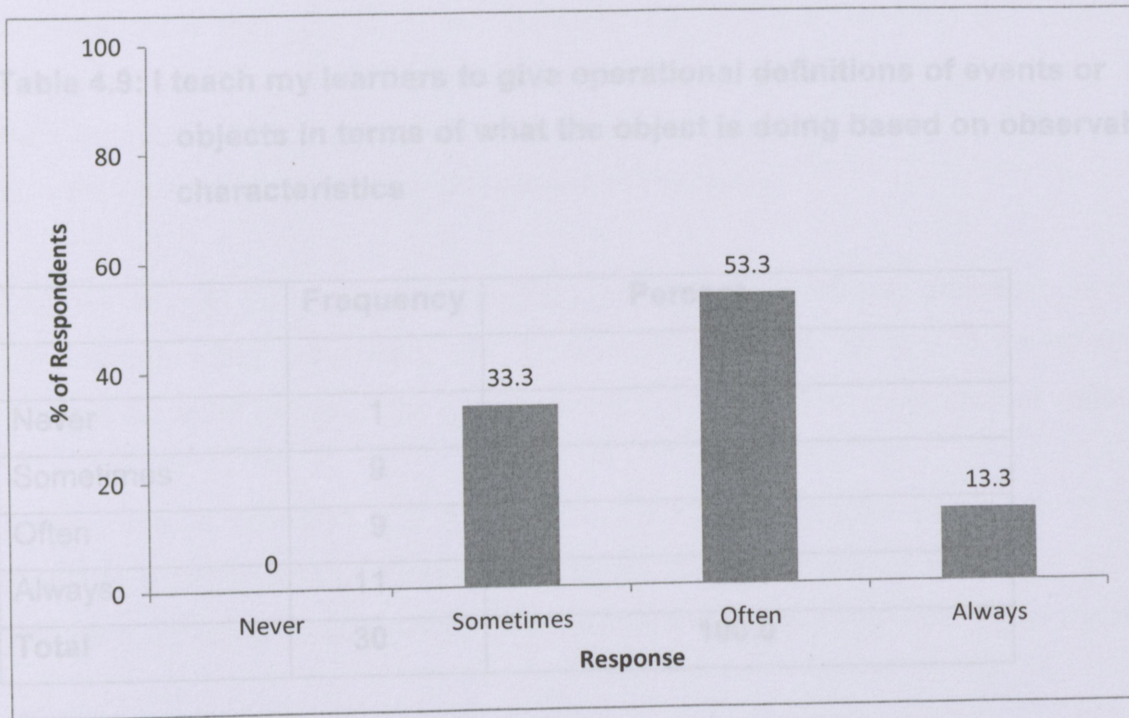
Communication is the means by which purpose and usefulness are given to scientific investigation.

#### 4.9 USING TIME-SPACE RELATION

**Table 4.8: I teach my learners to be able to use space/time relations to describe an object's position i.e. above, below, beside etc in relation to space**

	Frequency	Percent
Never	0	0
Sometimes	10	33.3
Often	16	53.3
Always	4	13.3
<b>Total</b>	<b>30</b>	<b>100.0</b>

#### 4.10 OPERATIONALLY DEFINITION



**Figure 4.8: I teach my learners to be able to use space/time relations to describe an object's position i.e. above, below, beside etc in relation to space**

It is pleasing to note that 86,6% of the teachers are teaching this skill to learners so that they will be able to apply this skill. This skill involves the ability to discern and describe directions, spatial arrangements, motion and speed, symmetry and rate of change KPLI and KDPM.

Using space/time relations is a process meant to describe a location, direction, shape and size of an object and its changes in a period of time. It also involves describing changes in parameters with time. Examples of parameters are locations, directions, shape, size, volume, weight and mass.

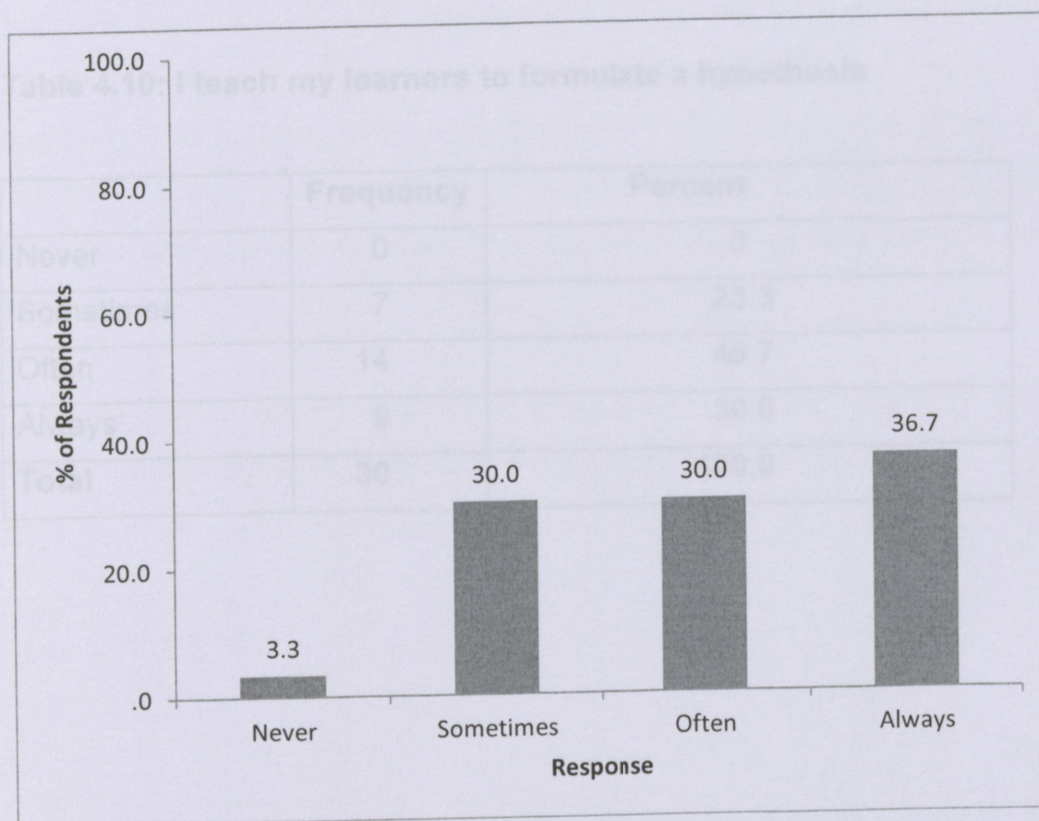
**Figure 4.9: I teach my learners to give operational definitions of events or objects in terms of what the object is doing based on observable characteristics**

#### 4.10 OPERATIONALLY DEFINITION

**Table 4.9: I teach my learners to give operational definitions of events or objects in terms of what the object is doing based on observable characteristics**

	Frequency	Percent
Never	1	3.3
Sometimes	9	30.0
Often	9	30.0
Always	11	36.7
<b>Total</b>	<b>30</b>	<b>100.0</b>

#### 4.11 FORMULATING HYPOTHESIS



**Figure 4.9: I teach my learners to give operational definitions of events or objects in terms of what the object is doing based on observable characteristics**

The majority of teachers are applying these skills to their science lessons. The findings show that 66,7% of the teachers are willing to develop this skill in their learners. However, 3,3% of the teachers are not engaged in developing this skill in their learners. Defining operationally describes exactly what the variables are and how they are measured within the context of the study.

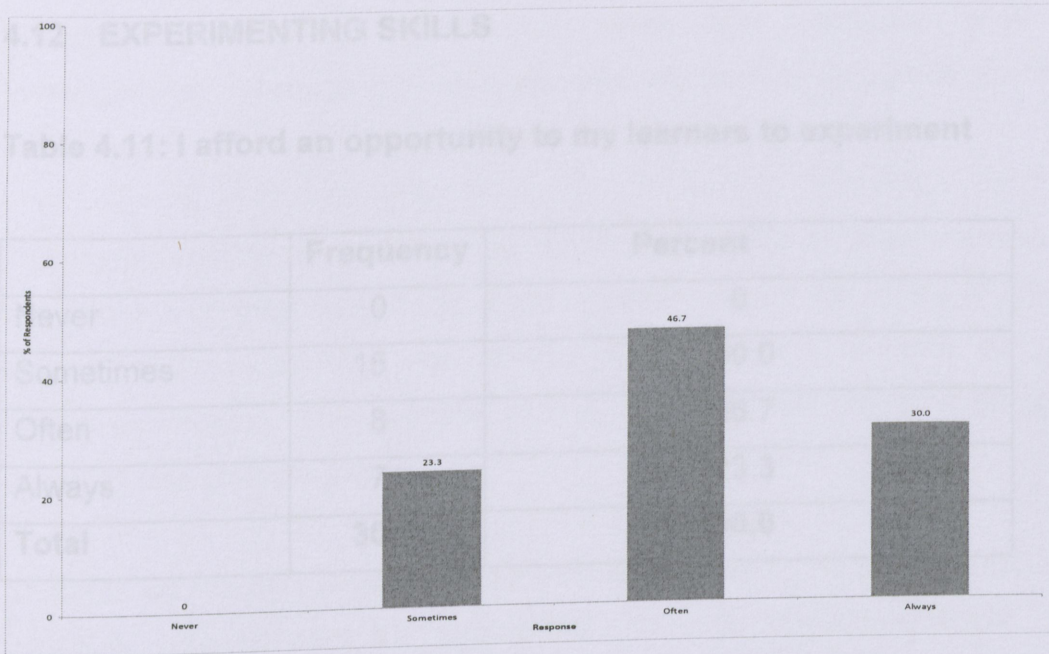
Learners should be taught that the main purpose of operational definitions is control. By understanding what they are measuring, they can control it by holding the variable constant between the groups or manipulate it as an independent variable.

An operational definition is a description of the one particular way in which you will measure a dependent variable. Operational definitions are necessary so that other scientists will know exactly what the dependent variable is and how it was measured.

#### 4.11 FORMULATING HYPOTHESIS

**Table 4.10: I teach my learners to formulate a hypothesis**

	Frequency	Percent
Never	0	0
Sometimes	7	23.3
Often	14	46.7
Always	9	30.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.10: I teach my learners to formulate a hypothesis**

The number of teachers who teach this skill is 76,7%. The findings revealed that 3,3% of the teachers are reluctantly applying this skill in the Physical Science lessons. All the teachers applied this skill in their classes, though with varying degrees. The majority of Physical Science teachers are aware of the importance of this skill. If one understands that hypothesis skills are statements that predict an outcome and provide a potential explanation for an experiment, based on prior knowledge.

Learners should be encouraged to state the expected outcome of an experiment. This is the best method to develop the formulation of a hypothesis.

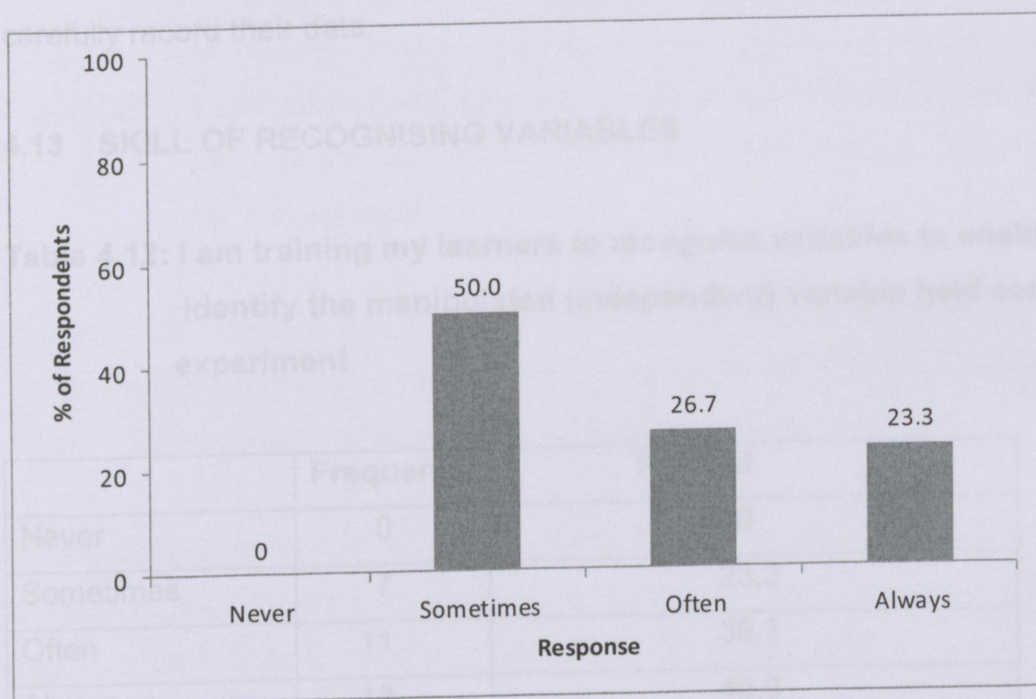
Figure 4.11: I afford an opportunity to my learners to experiment

Experimenting simply means being able to conduct an experiment. This includes asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a 'fair' experiment, conducting the experiment and interpreting the results of the experiment.

## 4.12 EXPERIMENTING SKILLS

**Table 4.11: I afford an opportunity to my learners to experiment**

	Frequency	Percent
Never	0	0
Sometimes	15	50.0
Often	8	26.7
Always	7	23.3
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.11: I afford an opportunity to my learners to experiment**

Experimenting simply means being able to conduct an experiment. This includes asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a 'fair' experiment, conducting the experiment and interpreting the results of the experiment.

Through experimenting, learners can utilise safe procedures while conducting investigations. Through this skill, learners are able to recognise the limitations of methods and tools used in experiments.

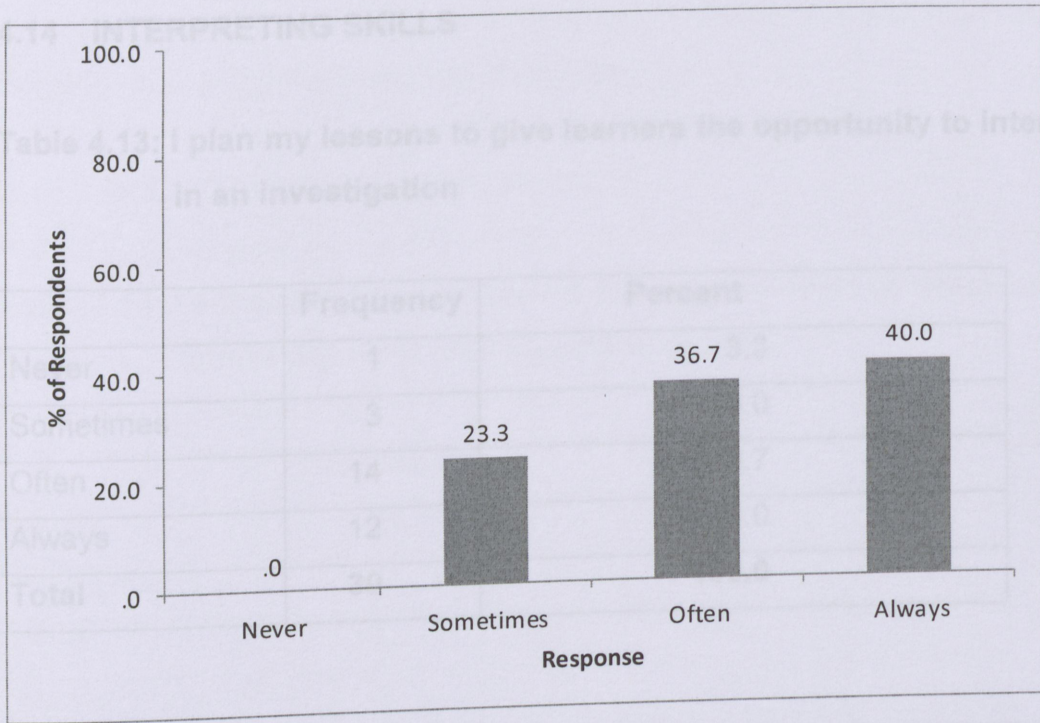
The findings show that 50% of the teachers are able to allow learners to perform experiments on their own. 50% of the respondents are also trying to afford students an opportunity to perform experiments. With guidance, students can design their own experiments. This process skill is integrated with hypothesising, controlling variables and collecting data.

Students can identify which variable they want to test, and thus, control all the other variables. To conduct the experiment, students observe changes, if any, and carefully record their data.

#### 4.13 SKILL OF RECOGNISING VARIABLES

**Table 4.12: I am training my learners to recognise variables to enable them to identify the manipulated (independent) variable held constant in an experiment**

	Frequency	Percent
Never	0	0
Sometimes	7	23.3
Often	11	36.7
Always	12	40.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.12: I am training my learners to recognise variables to enable them to identify the manipulated (independent) variable held constant in an experiment**

The findings revealed that 23,3% of the teachers train their learners to recognise variables, though not on a regular basis. However, 76,7% of the teachers train their learners to recognise variables while performing experiments.

Recognising variables involves identifying the manipulated (independent) variable, the responding (dependent) variable, and variables – held constant in an experiment. Learners are trained to control the variable in an investigation.

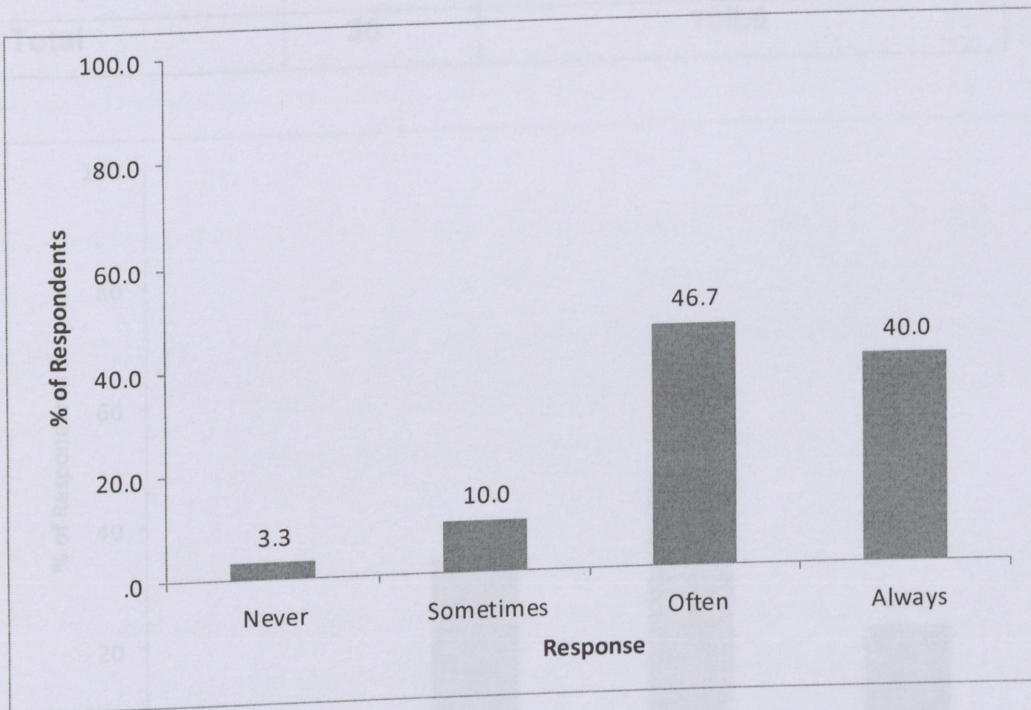
**Figure 4.13: I plan my lessons to give learners the opportunity to interpret data in an investigation**

Learners can analyse and share their results by interpreting data and inferring and communicating. Recording data in a chart and making a graph helps students to look for patterns in the data and draw conclusions about what the data mean. The findings show that 86, 7% of the respondents consider the interpretation of data as

#### 4.14 INTERPRETING SKILLS

**Table 4.13: I plan my lessons to give learners the opportunity to interpret data in an investigation**

	Frequency	Percent
Never	1	3.3
Sometimes	3	10.0
Often	14	46.7
Always	12	40.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.13: I plan my lessons to give learners the opportunity to interpret data in an investigation**

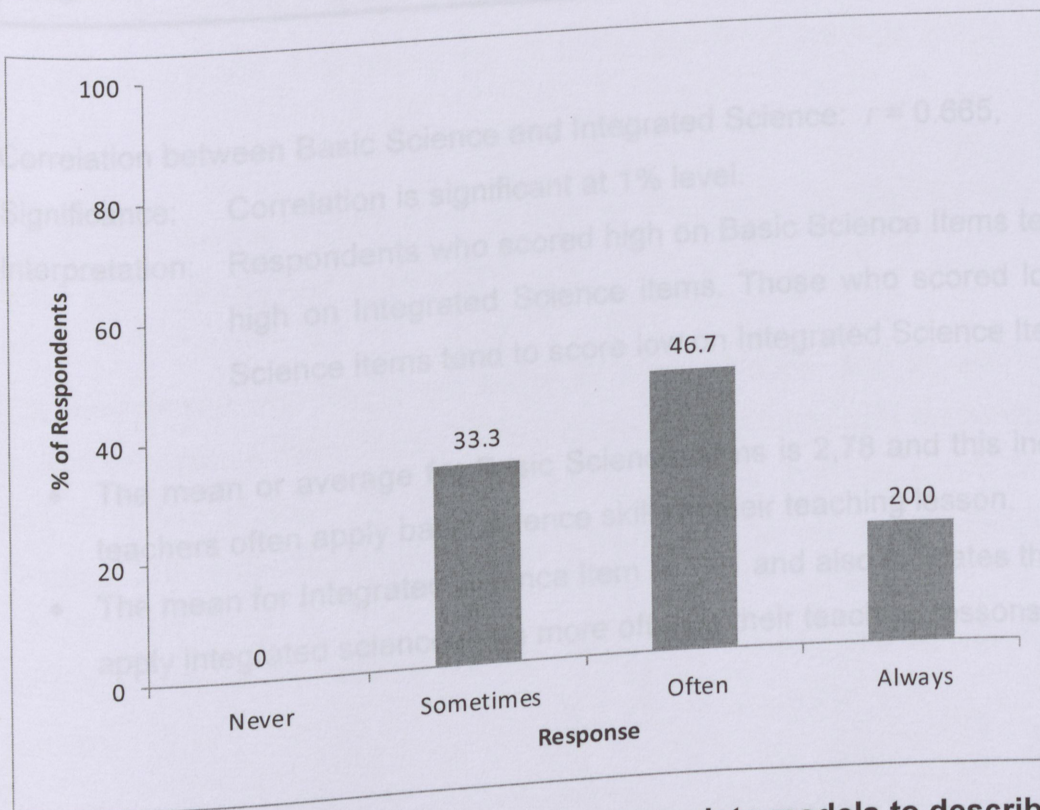
Learners can analyse and share their results by interpreting data and inferring and communicating. Recording data in a chart and making a graph helps students to look for patterns in the data and draw conclusions about what the data mean. The findings show that 86, 7% of the respondents consider the interpretation of data as

an essential skill for scientific investigation. However, 3,3% of the teachers do not consider the skill in their teaching strategies.

#### 4.15 SKILL OF FORMULATING MODELS

**Table 4.14: I encourage my learners to formulate models to describe interrelations of idea objects or events**

	Frequency	Percent
Never	0	0
Sometimes	10	33.3
Often	14	46.7
Always	6	20.0
<b>Total</b>	<b>30</b>	<b>100.0</b>



**Figure 4.14: I encourage my learners to formulate models to describe interrelations of idea objects or events**

Formulating models involves creating a mental, physical, or verbal representation of an idea, object or event. It stimulates the use of models to describe and explain interrelationships of ideas, objects or events.

The findings revealed that 80% of the teachers are in the process of encouraging learners to formulate models to describe interrelations of ideas objects or events.

#### 4.16 SUMMARY

##### Average Scores on Basic and Integrated Science Items:

	Number of Respondents	Mean	Std. Deviation
Basic Science (Items 1 – 9)	30	2.78	0.38
Integrated Science (Items 10 – 25)	30	3.01	0.47

Correlation between Basic Science and Integrated Science:  $r = 0.665$ ,

Significance: Correlation is significant at 1% level.

Interpretation: Respondents who scored high on Basic Science Items tend to Score high on Integrated Science items. Those who scored low on Basic Science items tend to score low on Integrated Science Items.

- The mean or average for Basic Science Items is 2,78 and this indicates that teachers often apply basic science skills in their teaching lesson.
- The mean for Integrated Science Item is 3,01 and also indicates that teachers apply integrated science skills more often in their teaching lessons.

### Cross tabulation of Basic Science Scores against Integrated Science Scores:

Basic Science Group		Integrated Science Group		Total
		Average Score	High Score	
Low Score	Count	1	0	1
	% within Basic Science Group	100.0%	.0%	3.3%
Average Score	Count	14	9	23
	% within Basic Science Group	60.9%	39.1%	76.7%
High Score	Count	0	6	6
	% within Basic Science Group	.0%	100.0%	20.0%
Total	Count	15	15	30
	% within Basic Science Group	50.0%	50.0%	100.0%

Fifteen (15) out of the thirty (30) respondents (50%) scored in the average group for Integrated Science. The remaining 15 (50%) scored in the high group for Integrated science.

For Basic Science, 6 (20%) had a high scores, while 23 (76.7%) had an average score and 1 (3.3%) had a low score.

The one person who had a low score for basic science, had an average score for integrated science. Fourteen (14) out of the twenty three (23) respondents (60.9%) had an average score for Basic Science, had an average score for Integrated Science. The remaining 9 (39.1%) had a high score on integrated science.

All 6 respondents that scored high for Basic Science also scored high for integrated science.

HO: No correlation between basic and international science

HE: A significant correlation between basic and international science.

The hypothesis of “no correlation between the basic science and international science” was not accepted.

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.1 INTRODUCTION

A discussion of the research results is presented in this section. Firstly, a general overview of the research results is discussed and presented. Data generated from educators are then discussed separately. Following this discussion, information collected from the questionnaires are interpreted and outlined.

### 5.2 GENERAL OVERVIEW

The purpose of this study was to describe the Physical Science Educators' perceptions of the development and application of basic and integrated process skills during Physical Science lessons. As noted in Chapter One (1), different chapters were outlined in the study as follows:

**Chapter One** described the introduction and provided a theoretical background to the study. The problem was stated and the purpose discussed. Certain concepts were explained and the research methodology outlined.

**Chapter Two** reviews existing literature on science process skills, the nature of science, integrated and basic process skills.

**Chapter Three** described the methodology used to collect data and the research design.

**Chapter Four** presented findings and discussed the results obtained from the questionnaires, teacher assessment activity, as well as their implications.

**Chapter Five** presented the conclusions and the recommendations that may assist educators to improve their practices in the teaching of Physical Sciences.

### 5.3 MAJOR FINDINGS OF THE STUDY

The first research sub-question was: *What do science educators perceive as basic and integrated process skills?* The answer to this question suggests that the educators' understanding of science process skills plays a pivotal role in their development and application 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, 2006:13). Data generated from this study suggest that the educators' understanding of the concept of science process skills influenced their confidence and ability to teach science through basic and integrated skills. Researchers such as Webb and Glover (2004), Wenham (2005) and Wessels (1998) argue that the educators' understanding of any area of science influences their classroom practices.

Furthermore, it was evident from this study that the beliefs held by each educator about their role and how the learners learn directly influenced their instructional decisions. The lack of appropriate learning materials and resources, the lack of professional continuous development and resistance to change, coupled with a lack of confidence in their teaching abilities, may explain why educators find it difficult to change their classroom practices.

The second question was: *How do science educators develop basic and integrated skills during their Physical Science lessons?* It is evident that learners spend a larger amount of time using skills such as observation and communication. As learners progress to higher grades, they tend to spend more time using the skills of inference and prediction. Classification and measurement tend to be used across the grade levels more evenly, partly because there are different ways to classifying, in increasingly complex ways, and because methods and systems of measuring must also be introduced to learners gradually over time.

Question three was *'To what extent are the basic and integrated process skills developed among learners in secondary schools?'* Developing the basic and integrated science process skills and gradually developing abilities to design fair

tests is increasingly emphasised in successive grade levels. This question was well responded to by educators.

From this study, it was also clear that training programmes provided by the DoE did not have any lasting impact on the educators' science practices. Fullan and Hargreaves (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 he/she acted in the past. However, 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 relate to with the Natural Sciences document owing to her lack of understanding of the terms used in it. This view is reinforced by Blignaut (2009:15) 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".

#### 5.5.1 Appropriate Learning Materials and Realistic Support

In addition, data gathered from the educators revealed that they assessed their 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.

Physical Sciences facilitators (district officials) to date have been limited and focused

structures and curricular documents such as learning programmes, work schedules, lesson plans and assessment activities. It is

### 5.4 CONCLUSIONS

Data generated from the educators 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 driving factors in the implementation thereof. Another factor that is of great concern is the educators' lack

noted earlier, development implies "change in practice" (Fullan, 2007:30). Verbal reactions from the educators revealed that they were not supported by the DoE to

of understanding of the formal continuous assessment tasks which determine whether a learner should be retained or should proceed to the next grade.

Based on the analysis of the data, this therefore study suggests that high quality and continuous support in the implementation of science process skills is crucial in order to enhance the educators' understanding of these important skills and concepts.

## **5.5 RECOMMENDATIONS PERTAINING TO THE STUDY**

Based on the analysis of data, educators suggested three main recommendations that they felt would promote a better understanding of process skills, and, in turn, increase the effective implementation of these skills in their Physical Sciences lessons.

### **5.5.1 Appropriate Learning Materials and Realistic Support**

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 Physical 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 they should also focus on intensive classroom visits so that educators are supported and guided in a realistic and practical manner (Govender, 2007).

### **5.5.2 Continuous and Supportive 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, 2007:30). Verbal reactions from the educators revealed that they were not supported by the DoE to

change their classroom practices so as to align them 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 in which inquiry teaching strategies are instilled and developed.

The other most important thing will be the realisation that Science Process skills are 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 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 materials, 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.

### 5.5.3 Professional Learning Communities

The notion of "professional learning communities", according to Blignaut (2005), is increasingly gaining recognition in literature. 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 resist complex, conceptual and longitudinal changes. As a practitioner and in conversation with other educators, the researcher noted 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.

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The study will be useful both to the Department of Education and Physical Science educators to value of teaching and learning of Physical Science.

The other most important thing will be the realisation that Science Process skills are a tool to nourish future scientists with necessary skills to advance innovation and research skills.

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### 5.6 RECOMMENDATIONS FOR FURTHER STUDY

It is further recommended that the study be extended to other regions of South Africa since the development of science process skills in the teaching of Physical Science is very critical nation-wide.

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APPENDIX A: QUESTIONNAIRES

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Never	
Sometimes	
Often	
Always	

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## APPENDICES

### APPENDIX A: QUESTIONNAIRES

UNIVERSITY OF VENDA

SCHOOL OF EDUCATION

#### TOPIC: The State of Development of Science Process Skills in the Teaching of Physical Science in Secondary Schools

Note: Please be advised that this information is confidential and will be handled with integrity. It is anonymous, so please feel free to give your honest answers as this questionnaire will not reveal the respondent's identity.

#### Instructions

- Answer all questions in sections A and B.
- There is no wrong or right answer.
- Please mark with a cross(x) where it is applicable.

#### SECTION A: BASIC SCIENCE PROCESS SKILLS

1. I let my learners observe objective events in a variety of ways using one or more of their senses.

Never	
Sometimes	
Often	
Always	

2. I let my learners use indirect methods and devices such as hand lamps, microscopes and thermometer to observe events and objects.

Never	
Sometimes	
Often	
Always	

3. My lessons require learners to group objects by their properties or similarities.

Never	
Sometimes	
Often	
Always	

4. I use activities in my lessons that require learners to infer explanations for events based on observations (hypothesis)

Never	
Sometimes	
Often	
Always	

5. I expect my learners to predict or forecast a future event based on prior experiences such as observations, inferences or experiments (any one of them)

Never	
Sometimes	
Often	
Always	

6. I teach my learners to measure accurately using length.

Never	
Sometimes	
Often	
Always	

7. I let my learners have the opportunity to handle instruments used to measure volume appropriate units.

Never	
Sometimes	
Often	
Always	

8. I demand that my learners write reports to communicate knowledge gained from discussions and/or observations.

Never	
Sometimes	
Often	
Always	

9. I request my learners to communicate data collected in table form.

Never	
Sometimes	
Often	
Always	

## SECTION B: INTEGRATED SCIENCE PROCESS SKILLS

10. I teach my learners to use space/time relations to describe an object's position, that is, above, below, beside etc in relation to space.

Never	
Sometimes	
Often	
Always	

11. I let my learners practice space/time relations to describe motion.

Never	
Sometimes	
Often	
Always	

12. I teach my learners to give operational definitions of events or objects in terms of what the object is doing, based on observable characteristics.

Never	
Sometimes	
Often	
Always	

13. I teach my learners to formulate a hypothesis.

Never	
Sometimes	
Often	
Always	

14. I expect my learners to be able to formulate hypothesis if they are provided with questions or predictions.

Never	
Sometimes	
Often	
Always	

15. I afford an opportunity to my learners to experiment.

Never	
Sometimes	
Often	
Always	

16. I let my learners recognise limitations of methods used in experiments.

Never	
Sometimes	
Often	
Always	

17. I am training my learners to recognise variables to enable them to identify the manipulated (independent) variable held constant in an experiment.

Never	
Sometimes	
Often	
Always	

22. 18. I am training my learners to recognize variables to be able to identify the manipulated responding (dependent) variable held constant in an experiment.

Never	Never	
Sometimes		
Often		
Always		

19. I train my learners to recognize how to control the variables in an investigation.
23. my learners to formulate models to describe interrelations of ideas objects or events.

Never		
Sometimes		
Often		
Always		
Always		

20. I plan my lessons to give learners the opportunity to interpret data in an investigation.
24. my learners to formulate models to explain interrelations of ideas objects or events.

Never		
Sometimes		
Often		
Always		
Always		

21. I urge my learners to interpret data gathered on investigations on which conclusions can be drawn.

Never		
Sometimes		
Often		
Always		

22. I require my learners to make use of evidence in making predictions. I to make predictions.

Never	
Sometimes	
Often	
Always	

23. I encourage my learners to formulate models to describe interrelations of idea objects or events.

Thank you for taking your time to fill in this questionnaire.

Never	
Sometimes	
Often	
Always	

24. I encourage my learners to formulate models to explain interrelations of idea objects or events.

Never	
Sometimes	
Often	
Always	

25. I expect my learners to explain how the evidence has been used to make predictions.

Tel. 082760 5718

Never	
Sometimes	
Often	
Always	

School of Education  
University of Venda  
Thohoyandou

Dear Teacher,

I am currently conducting research into the state of development of science process skills in the teaching of physical science in secondary schools.

**Thank you for taking your time to fill in this questionnaire.**

I have been granted permission by the Limpopo Education Department to conduct research in the school in which you are currently teaching as it has been selected to take part in this research.

1. A questionnaire will be administered and it may take 20 minutes to complete.
2. There is no known risk involved in the research.
3. There are no costs involved.

You are assured that your identity and responses to this questionnaire will be regarded as extremely confidential at all times and that they will not be made available to any unauthorized user.

Should you have any queries or comments, you are welcome to contact me.

N.E. Maunela

---

## APPENDIX B: LETTER TO TEACHERS

Tel. 082780 6718

In terms of the ethical requirements of the University of Venda, you are now requested to complete the following section:

School of Education

University of Venda

Thohoyandou

have read this letter and understand the terms involved.

On condition that the information provided by me is treated as confidential at all times and that it will not be made available to any unauthorised user. (MARK the appropriate section).

Dear Teacher,

I am currently conducting research into the state of development of science process skills in the teaching of physical science in secondary schools.

do NOT give consent that the results may be used for research purposes.

I have been granted permission by the **Limpopo Education Department** to conduct research in the school in which you are currently teaching as it has been selected to take part in this research.

Signature: \_\_\_\_\_

1. A questionnaire will be administered and it may take 20 minutes to complete.
2. There is no known risk involved in the research.
3. There are no costs involved.

Date: \_\_\_\_\_

You are assured that your identity and responses to this questionnaire will be regarded as **extremely confidential at all times and that they will not be made available to any unauthorised user.**

Should you have any queries or comments, you are welcome to contact me.

N.E Maumela

---

## CONSENT

In terms of the ethical requirements of the University of Venda, you are now requested to complete the following section:

I \_\_\_\_\_

have read this letter and understand the terms involved.

On condition that the information provided by me is treated as confidential at all times, I hereby (MARK the appropriate section).

give consent

do NOT give consent that the results may be used for research purposes.

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

APPENDIX C  
RAW DATA

Item>	Respondent
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25

APPENDIX C  
RAW DATA

Item>

Respondent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	3	3	3	3	3	4	4	3	4	4	3	3	4	4	3	3	3	3	4	4	4	4	3	3	4
2	2	2	2	2	3	2	3	2	2	2	2	2	3	3	2	2	3	3	3	3	3	3	4	4	3
3	3	3	3	3	2	1	2	4	3	3	3	2	3	3	2	2	2	2	3	3	3	3	3	3	2
4	2	2	2	2	2	2	1	3	4	2	2	2	3	3	2	3	3	3	3	3	1	3	2	3	3
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