EXPLORING SOUTH AFRICAN GRADE 10 LEARNERS' KNOWLEDGE ABOUT SCIENTIFIC INQUIRY IN SCHOOL SCIENCE

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DECLARATION

I, **MOJEKWU EMMANUEL OGOCHUKWU** declare that:

EXPLORING SOUTH AFRICAN GRADE 10 LEARNERS' KNOWLEDGE ABOUT SCIENTIFIC INQUIRY IN SCHOOL SCIENCE

is my own work and that all sources quoted have been indicated and acknowledged by means of complete references and that this dissertation has not been previously submitted by me for a degree at this or any another university.

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DATE

CERTIFICATE OF ACCEPTANCE FOR EXAMINATION

This dissertation entitled, *Exploring South African Grade 10 Learners Knowledge about Scientific Inquiry in School Science* by Mojekwu Emmanuel Ogochukwu is hereby recommended for acceptance for examination.

Supervisor

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Dr. Washington T. Dudu

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ABSTRACT

This study investigates South African Grade 10 learners' understandings about scientific inquiry and the implications of their views in relation to the outcomes of the new curriculum, Curriculum and Assessment Policy Statements (CAPS). The study sought to explore learners' understandings about specific characteristics of scientific inquiry. These characteristics include: *scientific investigations beginning with a question*; *there being no single set or sequence of steps followed in all investigations*; and *inquiry procedures being guided by the questions asked*. Implications of learners' scientific inquiry understandings in relation to the expected outcomes of the curriculum were inferred. The study followed a generic qualitative case study design, as the researcher sought to understand the nature, dynamics and complexity of learners' views about scientific inquiry. This was essential in getting to understand what works to improve Grade 10 learners' understandings about scientific inquiry. Sixty-seven Grade 10 learners from two schools in one village of the North-West Province were purposively sampled because of their proximity and accessibility to the researcher. The results revealed that participants hold different views and find it difficult to understand that: an investigation must have a hypothesis; a scientific investigation must have variables; a scientific investigation follows only one method; and there is a difference between an investigation and an experiment. The implication for this is the possibility that the learners might not be given opportunities in their schools to carry out different kinds of investigation in order to exhibit epistemic scientific inquiry. As seems the case, then, learners might be denied a chance to engage in the practices of science which in turn might help them to understand how scientific knowledge is developed and practiced as implicitly laid out in the South African CAPS documents. The results of the study have important implications for the development of scientific literacy in the South African educational settings. While authentic inquiry remains an ideal of science education, the achievement of informed views about the nature of scientific inquiry might be a realistic target in the South African context including poorly resourced contexts. The study recommends that more research should be undertaken to understand South African learners' views about scientific inquiry. Research should also be conducted on how knowledge about scientific inquiry actually develops in science classrooms.

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CHAPTER 1

BACKGROUND AND RATIONALE OF THE STUDY

1.1 INTRODUCTION

This study investigates learners' understandings about scientific inquiry. These understandings are studied within the context of eliciting Grade 10 learners' knowledge about scientific inquiry sampled from two rural schools in the North-West Province of South Africa. Inquiry refers to the diverse procedural ways in which scientists study the natural world and propose explanations based on the evidence derived from their work (National Research Council, 2000). Inquiry thus refers to activities related to understandings about scientific ideas, with the focus of the activity being a quest for knowledge or understanding to satisfy a curiosity.

Scientific inquiry refers to a combination of general science process skills with traditional science content, creativity and critical thinking to develop empirical scientific knowledge (Lederman, 2009). In other words, scientific inquiry denotes the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work (Grandy & Duschl, 2007), and as a result, scientific inquiry has been a perennial focus of science education. In school science, scientific inquiry refers to the characteristics of the processes through which scientific knowledge is nurtured and developed. This includes the conventions of development, acceptance, and utility of scientific knowledge. In the process, learners use their creative thinking to ask and answer questions in the classroom. Learners' understandings about scientific inquiry become the processes of learning by constructing knowledge from experience. According to Lederman (2007), learners' understandings about scientific inquiry involve higher order critical thinking by asking questions, designing experiments and conducting minds-on investigations and presenting findings. This promotes learning through construction of one's own knowledge and is generically centred on the learner's worldviews.

Scientific inquiry refers to the characteristics of the processes through which scientific knowledge is developed (Abd-EL-Khalick, et al., 2003). On the other hand, nature of scientific inquiry aspects are those that pertain most to the *processes of inquiry*, the *how* *component in* knowledge generation and how that knowledge is ultimately accepted (Schwartz, et al., 2008). Examples of scientific processes include observing, hypothesizing, experimenting, concluding and inferring. NOSI was defined as an individual's ideas, beliefs, and assumptions and understandings about the scientific process; what scientists do and how scientific knowledge is developed and validated. When this broad definition is examined closely, it is apparent that there are such terms as ideas, beliefs, assumptions and understandings that require further explication.

Learning science through inquiry is a dominant feature in international science education research, curriculum reform and instruction. For example, commitments to inquiry have become hallmarks of science education around the world from the United States to the United Kingdom and Australia (Grandy & Duschl, 2007). South Africa has also moved towards inquiry learning in secondary school science. This is attested to by its new science curriculum (Department of Education, 2010), which advocates the promotion of both inquiry learning and teaching. The focus of this study is on views about scientific inquiry (VASI), which is directly connected to an understanding about scientific inquiry. Often times, a learner's knowledge about scientific inquiry is not explicitly assessed, and it is assumed that students who do inquiry as advocated by the new curriculum would necessarily develop an understanding about inquiry. Not much research has been done to explore and validate such an assumption. Hence, the study being reported here fills an important niche. In South Africa, only a few studies on inquiry-based science education have been reported, and these studies indicate limited use of inquiry in South Africa (e.g. Dudu & Vhurumuku, 2012; Ramnarain, 2010; Vhurumuku, 2011). To the best of my knowledge only a single study has been done on learner's views about scientific inquiry in South Africa by Gaigher, Lederman and Lederman (2014) with 105 Grade 11 learners from 7 schools across the socio-economic spectrum in a South African city. This study extends the knowledge of learners' understandings of scientific inquiry. There is dearth in studies exploring learners' knowledge about scientific knowledge. The study also in a way evaluates the extent to which curriculum intents and transactions match so as to inform both curriculum development and implementation as suggested by Maravanyika (1986).

1.2 THE SOUTH AFRICAN CURRICULUM

The South African Physical Sciences Curriculum is briefly discussed in order to give the full context in which this study was undertaken. In collaboration with international fashions and trends, South Africa introduced a new Physical Science curriculum in 2003 (Department of Education, 2003). The curriculum then was known as the National Curriculum Statement (NCS). Recently, the National Curriculum Statements (NCS) were introduced together with the Outcomes-Based Education philosophy in 2005, and have been revisited with a view to simplifying the original documents and the subsequent supporting documents (Subject and Learning Area Statements, Learning Programme Guidelines and Subject Assessment Guidelines) for all subjects. The aim was to produce national Curriculum and Assessment Policy Statements (CAPS) as a "refined and repackaged" version of the original documents, and not create new curricula. The refining and repackaging of both the General Education and Training (GET) phase, Grade 8-9 and Further Education and Training (FET) phase, Grade 10-12 science documents were completed, and CAPS was launched at FET starting at Grade 10 level in 2012. Both the current curriculum and its predecessor advocate the learning and teaching of science through inquiry.

1.3 THE PROCESS OF SCIENTIFIC INQUIRY

In *school science*, scientific inquiry involves learner-centred projects, with learners actively engaged in inquiry processes and meaning construction, with teacher guidance, to achieve meaningful understanding of scientifically accepted ideas targeted by the curriculum (Krajcik, Blumenfeld, Marx, & Soloway, 1994; Minstrell & van Zee, 2000; National Research Council, 1996; Roth, 2008). This entails using a variety of activities to develop learners' knowledge and understandings, both of scientific ideas and how scientists study the natural world. This involves what is called 'inquiry learning', as a strategy for learning both scientific ideas and the nature of inquiry. It is important for learners to distinguish between science as a way of knowing and other ways of knowing by recognizing that science provides evidence-based solutions to pertinent questions.

Learners' understandings 'about' scientific inquiry and 'of' scientific inquiry are two different constructs. The difference is that learners' understandings about scientific inquiry can be defined as the processes in which learners are involved in classroom experiences, and creative thinking that share a context in order to discuss issues related to scientific inquiry. This leads to classroom experiences that could be examined through the learning activities (Parson & Brown 2002, Pedersen & Liu, 2002). On the other hand, learners' understandings of scientific inquiry leads learners to asking and answering questions on scientific inquiry. This could be done using classes of summative or formative assessment tool in small or large scale learners (Mikalsen & Kolstoe, 2002). This study focuses on learners' understandings *about* scientific inquiry and not learners' understandings *of* scientific inquiry.

1.4 STATEMENT OF THE PROBLEM

Inquiry is typically taught in science classrooms by having learners conduct investigations or in general, by doing inquiry or by the immersion of learners in authentic contexts (Schneider, Krajcik, & Blumenfeld, 2005). This is assumed to develop learners' knowledge about scientific inquiry. The problematic nature of the assumption can be illuminated by a simple example. Learners are often asked to control variables when conducting investigations but may not necessarily have an informed conception of the purpose of doing this as it relates to the design. The argument put forward is that learners can participate in inquiry experiences, but unless instruction explicitly addresses common characteristics of scientific inquiry, learners are more likely to continue to hold naive conceptions (Metz, 2004). South Africa's new science curriculum - Curriculum and Assessment Policy Statement (CAPS) - assumes that by doing inquiry, learners come to varied understandings of the nature of scientific inquiry. There is nowhere in the curriculum where an explicit understanding about scientific inquiry is mentioned in the curriculum documents. Research has shown that doing inquiry does not necessarily translate into understandings about scientific inquiry (Bell et al., 2003; Clough & Olson, 2004; Wong & Hodson, 2008). What then exactly is the state of South African learners' understandings about scientific inquiry in relation to the expectations of the new curriculum? This is an interesting research issue. This study examines the epistemic outcomes of inquiry based learning on learners' activities which may indicate that engaging learners in inquiry might be insufficient to bring about desired changes as spelt out by the curriculum.

1.4.1 Purpose of the Study

This study investigates South African Grade 10 learners' understandings about scientific inquiry and the implications of their views in relation to the outcomes of the new curriculum - the CAPS.

1.4.2 Research Questions

The study is guided by two questions:

1. What are learners' understandings about specific characteristics of scientific inquiry, namely: *scientific investigations beginning with a question*; *there being no single set or sequence of steps followed in all investigations*; and *inquiry procedures being guided by the question asked* in the course of developing and nurturing scientific inquiry?

2. From literature survey, what are the implications of these understandings in relation to the expected outcomes of the curriculum?

1.5 THEORETICAL FRAMEWORK

A theoretical framework is a collection of interrelated concepts which guide the research, determining what concepts the researcher investigates and how the research ultimately analyses and interprets data (Borgatti & Foster, 1996). The study is framed along the lines of inquiry-based learning theory and guided by three interrelated but specific constructs on scientific inquiry which encompasses:

(1) all scientific investigations begin with a question and do not necessarily test a hypothesis;

(2) there is no single set of steps followed in all investigations (i.e. there is no single scientific method);

(3) inquiry procedures are guided by the question asked.

These three aspects were chosen mainly because of their relevance to the South African Physical Science curriculum. The aspects also provide an acceptable level of generality regarding the NOSI that could be accessible for a level such as Grade 10 (Clough, 2007). Furthermore, the elements carried by these aspects are consistent with current philosophical views of science and useful for combating learners' naive views of scientific inquiry.

1.5.1 Scientific investigations all begin with a question and do not necessarily test a hypothesis.

Lederman et al. (2013) assert that it is valid to think that observations spark interest before a question exists and that is part of science. However, it is important to distinguish science from just walking through this world and making observations about it. In other words, watching a baseball game is not doing science (Lederman et al., 2013). It is this very issue that is at the heart of learners not being able to ask valid scientific questions. Learners should have some specific knowledge in scientific inquiry that has been melded into some curious pattern or question. Learners cannot ask and answer questions if they do not have some knowledge about scientific inquiry. This is the practice followed in science investigations and in research in any area. We do not deny the importance of observing the world, but observing the world without a conceptual framework that guides our observations is not science. Furthermore, scientific investigations involve asking and answering scientific questions and comparing the answers with what scientists already know about the world (NRC, 2000). In order for scientific investigations to ‘‘begin’’ there needs to be a question asked about the world and how it works. Though these questions may originate through a variety of means (e.g. general curiosity about the world, a response to a prediction of a theory), congruent with the vision set forth in the Next Generation Science Standards (NGSS), students need to understand that, in general, science begins with questions (NGSS, 2013).

1.5.2 There is no single set or sequence of steps followed in all investigations

Science often looks like the scientific method because of an overreliance on experimental design. Scientific method can be defined as answering a research question or problem following a well-laid out procedure (NRC, 2000). Meanwhile, there are other ways that scientists perform investigations such as observing natural phenomena. The field of astronomy for example, relies heavily on ways of gathering data, drawing inferences, and developing scientific knowledge that do not follow the ‘‘scientific method’’, with descriptive and correlation research as two of the more prominent examples (NRC, 2012). Learners need to develop not only an understanding of the variety of research methods employed both across and within the domains of science, but that, in general, “scientist[s] use different kinds of investigations depending on the questions they are trying to answer’’ (NRC, 2000, p.20). Put in another way, these methods are guided by epistemological goals (Sandoval, 2004). This is supported by NRC, (2012) which states that learners should have the opportunity to plan and carry out several different kinds of investigations (p.61), including both laboratory 'experiments' and field observations for them to reach scientific conclusions, including the generation of scientific hypotheses. Learners should understand that there is no single universal scientific method to follow in the generation of scientific knowledge and that there are different methods and approaches used.

1.5.3 Inquiry procedures are guided by the question asked

Though scientists may design different procedures to answer the same question, these invariably need to be capable of answering the question proposed. The procedures implied by the scientific method (i.e. experimental design) are not always tenable approaches for answering certain questions as "control of conditions may be impractical (as in studying stars), or unethical (as in studying people), or likely to distort the natural phenomena (as in studying wild animals in captivity)" (AAAS, 1990). Views about scientific inquiry assert that learners should understand questions regardless of the fact that the approaches may differ both within and between scientific disciplines and fields (Lederman, Antink & Bartos, 2012). Furthermore, the method of investigation must be suitable for answering the question that is asked. In this study, learners should be engaging in the practices of science which help them to understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world (NRC, 2012, p.42).

1.6 SIGNIFICANCE OF THE STUDY

The findings of the research might make a contribution to the literature that already exists on scientific inquiry. The argument running through the study might also create a platform for future studies that may be influenced by the results. It might also provide additional information for learners to help in the improvement of the learners' understandings about scientific inquiry. Policy and programme developers who are concerned with issues which affect learners of science in schools such as performance issues may benefit from the contribution of the study by seeing where learners go wrong. Learners could also benefit as they would see where they stand regarding their views about scientific inquiry.

1.7 DELIMITATION OF THE STUDY

This study is delimited to two schools in one village of the North-West province which were purposively sampled because of their proximity and accessibility to the researcher. One Grade 10 class from each school with an average of 38 learners offering Physical Science and Life Science as subjects were purposively sampled. The study was conducted from a generic qualitative perspective as a case study. Interview data was collected from the six learners, three from each school also purposively sampled.

1.8 DEFINITION OF TERMS

Inquiry

In this study, inquiry is assumed to be taught in science classrooms by having students conduct investigations or in general by doing inquiry or by the immersion of learners in authentic contexts (Sadler, Burgin, McKinney, & Ponjuane, 2010). This is assumed to develop students' knowledge about scientific inquiry.

Scientific inquiry

Scientific inquiry refers to the combination of general science process skills with additional science content, creativity and critical thinking to develop scientific knowledge (Lederman 2009). The meaning of scientific inquiry has been debated for decades, and precise descriptions of what inquiry means for science education seem to vary as much as the methods of inquiry (Bybee, 2000). Scientific inquiry is also defined as the process of learning through investigations.

Scientific Investigations

Scientific investigations involve asking and answering questions and comparing the answer with what scientists already know about the world (NRC, 2000). Scientific inquiry is defined as a process in which learners take the initiative in finding answers to problems (Jones, Simon, Fairbrother, Watson & Black, 1992).

1.9 CHAPTER DIVISION

CHAPTER 1 - PROBLEM ORIENTATION: This chapter serves as an orientation to the problem of the study; it covers background, statement of the problem, aims of the research,

research questions, research design and methodology, significance of the study, definition of terms, limitations and delimitations.

CHAPTER 2 - LITERATURE REVIEW: This chapter focuses on a review of recent and relevant literature connected to the research questions asked at the onset of the study. The literature covered and analyzed is relevant to the topic of discussion. Sub-topics include: Scientific inquiry, South African science curriculum and practical work. Other aspects to be reviewed are: nature of scientific investigations, scientific investigations all begin with a question, inquiry procedures can influence the conclusion, difference between data and evidence, and inquiry procedures are guided by the question asked.

CHAPTER 3 - RESEARCH METHOD: This chapter focuses on the method. Key constructs of the research method used are discussed. These include: research design, population and sample, instruments for data collection, reliability and validity of research instruments, data collection and data analysis.

CHAPTER 4 - DATA PRESENTATION AND ANALYSIS: In this chapter, focus is on presentation of findings and analysis of data from learner questionnaires and interviews. This was done in relation to the research objectives and literature.

CHAPTER 5 - SUMMARY, RECOMMENDATIONS AND CONCLUSION: The chapter presents a summary of the entire study with reference to the purpose of study as well as findings and recommendations made.

1.10 CHAPTER SUMMARY

This chapter provided the orientation for the study by stating the background and rationale for conducting the study. The problem statement was outlined. The research aims and the research questions that guided the study were mentioned. A demarcation of what is contained in all the chapters of the study was provided. The next chapter deals with the review of literature relevant to the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter provides a review of related literature. The main objective of this chapter is to review the most recent literature relevant to the study. The literature review focuses on learners' understanding about scientific inquiry. The chapter also focuses on literature on scientific inquiry in general and the South African curriculum, as well as constructs constituting the theoretical framework. The chapter ends by giving a summary of the concepts identified in the review process.

2.2 SCIENTIFIC INQUIRY

Scientific inquiry is a process in which learners take the initiative in finding answers to problems (Jones, Simon, Fairbrother, Watson & Black, 1992). Scientific inquiry is seen as the processes of how scientists do their work and how the resulting scientific knowledge is generated, disseminated and accepted (Lederman et al., 2007). Scientific inquiry and nature of science (NOS) are often used as synonymous terms; although scientific inquiry and nature of science are not independent from one another there is a difference between these two notions (Lederman et al., 2007). Regardless of the two terms being used synonymously, this study is not on the nature of science but views about scientific inquiry (VASI). It can thus be said scientific inquiry involves activities of learners in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. Schwartz, Khishfe, Lederman, Mathews and Liu (2002) state that research on understandings about scientific inquiry has shown that neither teachers nor learners typically hold informed views of scientific inquiry (SI). Bell and Maeng (2010) raise an issue and say that even though it seems conceivable that learners who are actively engaged in scientific inquiry should develop more accurate understandings of science and the construction of scientific knowledge, there is virtually no research to support this assumption (p.4). The essential point here is that having learners experience authentic scientific inquiry is absolutely necessary, but it is not sufficient for the development of conceptual understandings about inquiry (Lederman, 2003; NRC, 2000). Learners need to explicitly address the reform – based goals related to knowledge about scientific inquiry and of science within traditional subject matter and scientific process skills.

Scientific inquiry refers to the characteristics of the processes through which scientific knowledge is developed (Abd-EL-Khalick, et al., 2003). On the other hand, nature of scientific inquiry aspects pertain most to the *processes of inquiry*, *how* the knowledge is generated and accepted (Schwartz, et al., 2008). Examples of scientific processes include observing, hypothesizing, experimenting, concluding and inferring. NOSI was defined as an individual's ideas, beliefs, and assumptions and understandings about the scientific process; what scientists do and how scientific knowledge is developed and validated. When this broad definition is examined closely, it is apparent that there are such terms as ideas, beliefs, assumptions and understandings that require further explication. The focus of this study is on learners' understandings of the nature of scientific inquiry and not on their practising of inquiry. In a nutshell, *scientific inquiry* is a process of active exploration by learners during which there is use deliberate use of critical, logical, and creative thinking skills to raise and engage in questions of curriculum relevance.

2.3 INQUIRY AND THE SOUTH AFRICAN CURRICULUM

Inquiry is generated by what is typically taught in science classrooms by having students conduct investigations or in general by doing inquiry or by the immersion of learners into authentic contexts (Sadler, Burgin, McKinney & Ponjuane, 2010). Inquiry as learning is a philosophy which has its roots in the works of Kirschner, Sweller & Clark (2006). According to Brandon, Young, Pottenger and Tanm (2009) inquiry learning is used as an approach that provides learners with opportunities to locate information in a wide range of contexts. More so, inquiry learning allows learners to discover meaning and relevance of information through a series of steps that involves making conclusions and reflecting on the newly attained knowledge (Prairie, 2005, Yager, 2009). According to Schwartz, Lederman and Crawford (2003) inquiry learning is associated with the theory of constructivism. Inquiry has grown in popularity in science education in the US since the cold war and has been explicitly promoted by the NRC (1996, 2000). The National Science Education Standards (NSES) describes inquiry as diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work (NRC, 1996, p.23). Different meanings are attached to inquiry in science education. These were described by the NRC

(1996) as an engagement in the processes of inquiry, knowledge about the inquiry process, and teaching by inquiry. However, inquiry learning is at the heart of the scientific enterprise, and as such, demands a prominent position in science teaching and learning (Bell, et al., 2010; Donovan & Bransford, 2005).

In South Africa, only a few studies on inquiry-based science education have been reported, and these studies indicate limited use of inquiry in South Africa (e.g. Dudu & Vhurumuku, 2012; Ramnarain, 2010; Vhurumuku, 2011). Consequently, it is important to explore learners' understandings about inquiry in South African schools. However, to the best of my knowledge, only a single study has been done on learners' views about scientific inquiry in South Africa by Gaigher, Lederman and Lederman (2014) with 105 Grade 11 learners from 7 schools across the socio-economic spectrum in a South African city. According to Hartshorne (1992), before the political transformation of 1994, education in SA was segregated on racial lines, with separate departments of education, curricula and funding for different racial groups. After democracy was attained in 1994, the education system has seen many changes to undo the damages of racial discrimination (Chisholm & Leyendecker, 2008). These changes included the introduction of Curriculum 2005 (C2005) in 1998. To the Department of Education [DOE] (1997), this was an ambitious effort to eliminate rote learning of content which characterized education prior to democracy in South Africa. Based on Spady's (1994) vision that outcomes be focused on higher levels of skills and life performance roles rather than on learning prescribed content, the new curriculum introduced Outcomes Based Education (OBE). Actually, C2005 did not prescribe any content, expecting teachers to develop their own learning materials suitable for their situations. To Jansen (1999), this ideal ironically was particularly difficult to achieve in previously disadvantaged schools where resources were lacking and teachers were poorly trained. Consequently, C2005 did not succeed in improving the quality of education for the disadvantaged majority for whom it was meant to secure a better future. Additionally, the short timeframe of introducing the curriculum change and the complex curriculum design resulted in implementation problems and severe criticism, leading to an early revision of C2005 (Chisholm, 2000).

Following the failure of C2005, other reforms to the curricula were implemented. The Revised National Curriculum Statement (RNCS), for preschool to grade 9, was introduced in 2003 (DOE, 2002) and the new high school curriculum, the National Curriculum Statement

(NCS), followed in 2006 (DOE, 2008) for Grade 10-12. In the reform curricula, the outcomes based principles and focus on skills envisaged in C2005 were retained although the RNCS and NCS did prescribe some content. Consequently, the RNCS and NCS curricula were also criticized in the South African media for their lack of emphasis on content. In actual fact, it was blamed for learners' poor performance in final school examinations (Pretoria News, 2009; Sunday Times, 2009) and international achievement tests such as TIMSS (Martin, Mullis, Gonzales & Chrostowski, 2004; Reddy, 2006; Reddy, Prinsloo, Visser, Arends, Winnaar, Rodgers, Van Rensburg, Juan, Feza & Mthethwa, 2012). The criticism resulted in the return to a content-driven curriculum, eight years after the implementation of the RNCS. The third generation of curriculum reform, named the Curriculum and Assessment Policy Statement (CAPS) was introduced in 2011 (Department of Basic Education [D BE], 2011).

The RNCS for science specified three learning outcomes: Learning Outcome (LO) (1), focusing on scientific inquiry and problem-solving skills, reads:

The learner should be able to use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts (Department Of Education, 2005);

Learning Outcome (2), focusing on constructing and applying scientific knowledge, reads:

The learner should be able to state, explain, interpret and evaluate scientific and technological knowledge and apply it in everyday contexts (Department Of Education, 2005); and

Learning Outcome (3), focusing on the nature of science and its relationship to technology, society and the environment says:

The learner should be able to identify and critically evaluate scientific knowledge claims and the impact of this knowledge on the quality of socio-economic, environmental and human development (Department Of Education, 2005).

While LO3 appears implicit about developing learners' nature of science (NOS) understandings, a closer examination of this outcome shows that learners' understandings of NOS is a pre-requisite for the achievement of this outcome. In order for learners to "identify and critically evaluate scientific knowledge claims," they must of necessity have an understanding of NOS.

Besides the three learning outcomes of the RNCS, assessment standards were specified as policy to provide a "common national framework for assessing the learner's progress" (p.46). For example, the following assessment standards were specified for the senior phase (Grades

7, 8 and 9):

- ✓ Planning investigations
- ✓ Conducting investigations and collecting data
- ✓ Evaluating data and communicating findings
- ✓ Recalling meaningful information when needed
- ✓ Categorising information to reduce complexity and look for patterns
- ✓ Interpreting information
- ✓ Applying knowledge to problems that are not taught explicitly
- ✓ Understanding science as a human endeavour in cultural contexts
- ✓ Understanding sustainable use of earth's resources

The third change of curriculum reform was brought in line with international trends. The new South African Physical Science Curriculum (Grades 10-12) advocates for developing learners' understandings of NOS (Department of Education (DOE), Curriculum Assessment and Policy Statement (CAPS) Document 2011). One of the specific aims of the CAPS document is to promote:

> ...knowledge and skills in scientific inquiry and problem solving; the construction and application of scientific and technological knowledge; an understanding of *the nature of science* and its relationships to technology, society and the environment. (DoE CAPS document, p. 6)

While the curriculum documents might have noble intentions, such as stated in the CAPS document, experience and research and sound curriculum practice categorically suggest that it is always important to critically assess and evaluate the extent to which curriculum intents and transactions match so as to inform both curriculum development and implementation (Maravanyika, 1986).

The belief that doing scientific inquiry is a sufficient condition for developing an understanding about scientific inquiry unfortunately is a misconception identified in the research on NOS (e.g. Wong & Hodson, 2009, 2010). Inquiry in school science is the theoretical construct guiding learners' experiences on scientific inquiry. According to Hofstein and Lunetta (2004), scientific inquiry (as practiced by professional scientists) refers to the various ways of studying the natural world, asking questions, proposing ideas, collecting data to justify assertions and explanations and communicating results. According to Dudu (2014), school *science* inquiry is seen as similar to the inquiry done by professional scientists as learners also investigate the world, propose ideas and justify explanations based on collected data. Chinn and Malhotra (2002), however, argue that school-based inquiry is cognitively and epistemologically different from authentic scientific inquiry (research done by scientists). It is noteworthy that the cognitive tasks needed for authentic science are more demanding than what is required for school science. Authentic scientific inquiry is a complex activity employing expensive equipment, elaborate procedures and theories requiring highly specialized expertise for data analysis (Chinn & Malhorta, 2002). Schools lack the expertise, the resources and time to engage in authentic science. Epistemologically, school science is simple inquiry aimed at uncovering and verifying simple observable regularities whereas authentic science aims at uncovering new theoretical models and revising existing ones. Therefore, when examining inquiry in the context of *school science*, it should always be borne in mind that this inquiry is within the cognitive and epistemological boundaries of *school science.*

2.4 SCIENTIFIC INVESTIGATIONS ALL BEGIN WITH A QUESTION

A study by Lederman et al. (2013) asserts that it is valid to think that observations spark interest before a question exists and that is part of science However, it is important to distinguish science from just walking through this world and observing the permutations and combinations of natural elements. In other words, watching a baseball game is not doing science. Scientific investigations need to have specific knowledge that has been melded into some curious pattern or question (Lederman et al. 2013) Scientific investigations involve asking and answering questions and comparing the answers to what scientists already know about the world. The Next Generation Science Standards (NGSS, 2013) states that in order for scientific investigations to begin there needs to be a question asked about the world and how it works. Though these questions may originate through a variety of means (e.g. general curiosity about the world, a response to a prediction of a theory), students need to understand that, in general, science begins with questions. The Next Generation Science Standards (NGSS, 2013) states that many learners were unable to distinguish between experiments and investigations, though some showed a clear understanding of the difference between experiment and investigation. The learners who could not distinguish the difference between experiment and investigation intimated that only one method can be used in investigation. In this NGSS, many learners did not understand the word experiment, practical or testing.

2.5 THERE IS NO SINGLE SET OR SEQUENCE OF STEPS FOLLOWED IN ALL INVESTIGATIONS

There exists no single *scientific method* used by all scientists (Bell, et al., 2010). Meanwhile, scientists use a variety of approaches to develop and test ideas, to answer research questions and develop scientific knowledge (Bell, et al., 2010). The NRC(2000) states learners need to develop not only an understanding of the variety of research methodologies employed both across and within the domains of science, but that, in general, scientist[s] use different kinds of investigations depending on the questions they are trying to answer (p.20). The methods used in investigation are guided by epistemological goals (Sandoval, 2005). Furthermore, NRC (2011) states that learners need the opportunity to plan and carry out several different kinds of investigation in order to understand that investigations do not follow a single method or step. Learners should be quite aware that investigations are based on questions. However, many learners do not regard a question as an essential starting point for investigation. Rather it is often regarded as part of procedure, that a scientist decides to do an investigation and then formulates the question on their own.

2.6 INQUIRY PROCEDURES ARE GUIDED BY THE QUESTION ASKED

The AAAS (1990) states that scientists may design different procedures to answer the same question; these procedures invariably need to be capable of answering the question proposed. The procedures implied by the scientific method i.e. experimental design, are not always tenable approaches for answering certain questions as control of conditions may be impractical, as in studying stars, or unethical, as in studying people, or likely to distort the natural phenomena as in studying wild animals in captivity. A study by Lederman et al. (2013) found that most students are of the idea that all inquiry procedures are guided by the question asked. However, the NRC (2012) state that the procedure selected for a scientific investigation invariably influences the outcome. Furthermore, the method of investigation must be suitable to answering the question that is asked (Lederman, Antink, & Bartos, 2012). The study by Lederman et al. (2012), found that when assessed about procedures and questions asked, learners are of the understanding that scientists may come to different conclusions even when performing the same procedures due to the subjectivity of human interpretation. Many learners did not know that human factors influence interpretations and shape conclusions. The naive responses of the learners indicated that for them, similar procedures would always lead to the same results.

2.7 CHAPTER SUMMARY

This chapter provided an overview of the constructs scientific inquiry, inquiry and the South African curriculum context and aspects forming the conceptual framework of the study. These include the assertion that scientific investigations all begin with a question, there is no single set or sequence of steps followed in all investigations, and ultimately that inquiry procedures are guided by the question asked.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. INTRODUCTION

This chapter focuses on the research methods established as suitable for this study. Focus is on the definition of methodological terms and their operationalisation used to achieve the objectives of the study. The terms include: research design, population and sample, instruments for data collection, reliability and validity of research instruments, data collection and data analysis. Research methodology is defined as a highly intellectual human activity used in the investigation of nature and matter and also deals specifically with the manner in which data is collected, analysed and interpreted (Anju, 2013:9). On the other hand, Yin (2003:21) defines research methodology as a plan that guides the investigator in the process of collecting, analysing and interpreting observations.

3.2 RESEARCH PARADIGM AND DESIGN

3.2.1 Paradigm

According to Creswell (2009: 6), world view refers to a selection of beliefs that are used to direct actions in research. Some refer to world view as a paradigm and a researcher must choose the most appropriate to provide a view of the nature of reality (Blaxter, Hughes & Tight, 2010). It must however be noted that it is not easy to choose the best and that each different approach yields a different kind of knowledge about the phenomena under study (Blaxter et al. 2010: 59). This study adopts the pragmatic world view. The pragmatic approach, according to Creswell (2009: 11), offers to the study a philosophical base as it is flexible in the sense that researchers can freely choose methods, techniques or procedures that meet the needs and purposes of research. Both philosophically and methodologically, pragmatism offers a practical and outcome-oriented method of inquiry that is based on action to help the researcher better answer the research question. In this study, a qualitative approach was used to solicit learners' understandings about scientific inquiry. This is essential in getting to understand what really works to improve Grade 10 learners' understandings about scientific inquiry. In addition, the approach is perceived as relevant as it opens up to questions of 'what' and 'how' and also accommodates the use of views about scientific inquiry in school.

3.2.2 Design

The study followed a generic qualitative case study design, as the researcher wanted to understand the nature, dynamics and complexity of learners' views about scientific inquiry (Cohen et al. 2002). According to Kahlke (2014:1), generic qualitative studies are those that refuse to claim allegiance to a single established methodology. Kahlke (2014:2) further goes on to say that researchers find themselves with research questions that do not fit neatly within the confines of a single established methodology; generic studies offer an opportunity for researchers to play with these boundaries, use the tools that established methodologies offer, and develop research designs that fit their epistemological stance, discipline, and particular research questions. A generic qualitative case study is subsequently subdivided into genres of interpretive description and descriptive qualitative research. Caelli et al. (2003) have suggested that this can mean either that generic studies blend established methodological approaches in order to create something new or that they claim no formal methodological framework at all. This study employed the former. The case study research method was deemed appropriate for its in-depth characteristics and effectiveness in attaining a desired goal in a short time by emphasizing detailed contextual analysis of a limited number of events or conditions and their relationships (Çepni 2003).

A case study approach was adopted based on the suitability of such a design for the purposes of the study. According to Yin (1994) a case study is an empirical inquiry that "investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13). McMillan & Schumacher (2006) assert that in a case study the researcher focuses on one phenomenon in order to understand it in depth, where the one phenomenon "may be one administrator, one group of students, one programme, one process, one policy implementation, or one concept" (p. 316). While the general conception of a case study is based on its focus on a unit, some authors have classified case studies according to the purpose of the study (Bassey, 1999; Yin, 1994). Stenhouse (1985) describes an educational case study as concerned with the understanding of educational action and enriching the "thinking and discourse of educators either by the development of educational theory or by refinement of prudence through the systematic and reflective documentation of evidence" (p. 50).

3.2.3 Population

The target population, according to Fraenkel et al (2008: 90), refers to the actual large group to which the results of the information gathered is applied or generalized. For this study the target population consists of all Grade 10 learners in the North-West Province doing Physical science and Life science. Though narrowing the population limits generalizability, the study is not interested in generalizing since it follows a case study design. Each case is unique and findings from such a case reflect characteristics unique to the case and often cannot be generalized.

3.2.4 Participant selection

Sixty-seven (67) Grade 10 learners of two schools in one village of the North-West Province were purposively sampled because of their proximity and accessibility to the researcher. Purposive sampling involves selecting samples by considering their suitability for answering the research questions, providing the required information and serving the research purposes (Teddlie & Yu, 2007). The researcher works in one of the two purposively sampled schools; the other site is a nearby secondary school. There is only one Grade 10 class which is doing Physical Science and Life Science at each of the schools hence each Grade 10 class participated in the study. One Grade 10 class at one of the schools had 33 learners and the other Grade 10 class from the other school had 34 learners. All the learners were doing Physical Science and Life Science as school subjects.

3.3 DATA COLLECTION STRATEGIES

In this study, I explored views about scientific inquiry through use of an open-ended questionnaire and semi-structured interviews.

3.3.1 Questionnaire

3.3.1.1 The Views about Scientific Inquiry questionnaire (VASI)

The VASI instrument has the following eight aspects of SI:

(1) scientific investigations all begin with a question and do not necessarily test a hypothesis;

(2) there is no single set of steps followed in all investigations (i.e. there is no single scientific method);

(3) inquiry procedures are guided by the question asked;

(4) all scientists performing the same procedures may not get the same results;

(5) inquiry procedures can influence results;

(6) research conclusions must be consistent with the data collected;

(7) scientific data are not the same as scientific evidence; and that

(8) explanations are developed from a combination of collected data and what is already known.

These aspects are seen as educationally and developmentally appropriate in the context of kindergarten to high school science classrooms. Of these eight, only three were chosen for this study. As mentioned earlier, they were chosen because of their relevance to the South African Physical Science curriculum. These aspects also provide an acceptable level of generality regarding the NOSI that could be accessible for a level such as Grade 10 (Clough, 2007). Furthermore, the elements carried by these aspects are consistent with current philosophical views of science and useful for combating learners' naive views of scientific inquiry.

The Views about Scientific Inquiry questionnaire (VASI) instrument was adopted from Lederman, et al. (2014). The instrument was adapted from Views of Scientific Inquiry (VOSI) questionnaire (Schwartz, 2004; Schwartz et al., 2008). While the VOSI provided valid insights into respondents' views of scientific inquiry (Schwartz & Lederman, 2008; Schwartz et al., 2008), after scoring and reflecting on many VOSI items and responses, it was determined that this instrument did not assess the more comprehensive list of aspects of inquiry previously identified. As such, an updated version of the VOSI was desirable, and the VASI Questionnaire was the result of these efforts. The VASI was developed, validated and checked for reliability when an expert panel was assembled to guide the development of the new questionnaire. This group was comprised of two of the science educators who were part of the developmental team responsible for the creation of the original VOSI and VNOS questionnaires. In addition, 10 PhD students, all of whom have backgrounds in various contexts in science education, both as in-service teachers in Grades K-12 in a variety of content areas including physics, chemistry and biology, and who have likewise developed and provided professional development in science content, NOS, and SI were also included. Essentially the instrument measures views about scientific inquiry. In its original form, the instrument consists of 7-items each giving a scenario on how an individual harbours views about scientific inquiry. One example of items on the questionnaire is: *"Two students are asked if scientific investigations must always begin with a scientific question. One of the students says "yes" while the other says "no". With whom do you agree with and why?"* For the rest of the questions, see Appendix A. In this study only the first five items were used, the reason being that they are simpler and clearer for this grade level. The other two questions relate more to Life Sciences but the researcher is not comfortable with the subject. Thus the researcher chose the first five questions related to Physical Sciences. The instrument has been found to be internally consistent with high reliability estimates established after both Cronbach alpha reliability test estimates and Exploratory Factor Analyses were performed on it (Lederman, et al., 2014) with the group which developed it. According to Lederman, et al. (2014), it was felt that this group was the most informed for this undertaking, as they knew what they wanted to measure and were likewise acutely aware of the problems of measuring it. It should be noted that people external to the group (e.g., teachers) were employed in both the initial vetting of items and the reliability check. In general, to establish the content validity of the VASI questionnaire, all new questions were vetted by the committee, revised when necessary, and then confirmed to address the main aspect of SI with 100% agreement among the 12 committee members. The committee also ensured that all aspects of Scientific Inquiry (SI) were addressed. This process was identical to that previously described when examining the congruence of the VOSI and to further ensure validity with the eight essential aspects of SI. Another two groups of middle school students from grade eight over the course of two years (N = 111 year one, N =116 year two) completed the VASI at the start of the school year, and again following instruction. There were three teachers involved in instruction. These teachers met with a PhD student weekly over a 7-month-period to help them plan for explicit instruction targeting appropriate aspects of SI. These lesson plans included instructional objectives related to SI, formative and summative assessments of students' understandings, in addition to providing explicit-reflective instruction (Khishfe & Abd-El-Khalick, 2002). The same PhD student observed the lessons to gauge fidelity to the written plan. Instructional content related to SI was examined by the expert panel for congruence with the previously defined eight aspects.

3.3.1.2 Piloting the instrument

To validate the instrument, a version was administered to 30 Grade 10 learners from one class at one High School purposively and conveniently sampled (the school was not part of the sample for the main study), in the North-West province. After completing the instrument, 5 learners were again purposively selected based on their responses to the VASI. These learners were selected because they appeared to have given the most comprehensive answers in the questions of the VASI. Among other issues, the researcher found it necessary to check on learners' understandings of the complexity of the English language used in the questionnaire. This is because South Africa has eleven major official indigenous languages. For most Grade 10 South African learners who formed the population of the study, English is a second language if not third or fourth after Afrikaans, isiXhosa, isiZulu, or seTswana. First they were interviewed, individually (in the absence of the other learners and also ensuring that the learners did not mix to share answers) and later as a group about whether or not they had difficulties with understanding the complexity of the language in the questionnaire. The researcher went on to ask the learners individually to explain how they interpreted statements from the questionnaire. The five learners were also asked to comment on what they thought the instrument was designed to measure. It emerged that the learners understood that the questionnaire sought to elicit their views about scientific inquiry. Their class teacher was also asked to comment on their understanding of the spirit of the questionnaire.

3.3.2 Semi-Structured Interviews

Semi- structured interviews require the participant to answer a set of predetermined questions and allow for probing and clarification of answers (Maree 2010:87). To collect qualitative data, a semi-structured interview guide was developed. The interview guides were used to collect data from the six (6) learners, three from each school purposively sampled. The criterion for their selection was based on the fact the 6 had interesting views which they had given in the open-ended questionnaire and the researcher wanted to probe and get clarification of the responses the participants had given. All interviews were audio-recorded and transcribed verbatim. The interview questions were fashioned from literature (Lederman, et al., 2014). Questions from VASI were rephrased to provide the interview schedule. The questions were piloted with a different group of learners which was not part of the interview sample. These learners are from the same group who completed the VASI instrument during piloting. Examples of the interview questions are:

(a) Two students are asked if scientific investigations must always begin with a scientific question. One of the students says 'yes' while the other says 'no'. With whom do you agree and why?
(b) If several scientists ask the same question and follow the same procedures to collect data, would they necessarily come to the same conclusions? Say, why or why not?

The researcher personally conducted the interviews with the individual learners and their responses were recorded. Semi-structured interviews were used by the researcher on face-to-face basis to get insights into learners' understandings about scientific inquiry.

3.4 RESEARCH METHOD

In this study, views about scientific inquiry (VASI) questionnaire and semi-structured interviews were used to collect data from the learners. This process commenced with the researcher administering the questionnaire to learners in person and collecting them after completion for analysis. This assured a 100% return rate. Semi-structured interviews were conducted by interviewing individually (one learner at a time), probing each learner's VASI responses. The interviews were conducted with six (6) school learners, three from each school and the sampling was purposive. The selection was based on the learners VASI responses which are either ambiguous or need clarification. Both the VASI instrument and semi-structured interviews were used to help the researcher with examining, comparing, conceptualizing and categorizing data (White, 2002:82). The procedure began with the naming and categorizing of phenomena through close examination of data. White (2002:82) explains that data analysis in qualitative research is a systematic process of selecting, categorizing, synthesizing and interpreting of data to provide explanations of the single phenomenon of interest. In this way the researcher outlined the learners' understandings about scientific inquiry.

3.4.1 Qualitative Data Analysis

Qualitative data was analysed inductively. According to Leedy and Ormrod (2013), data analysis in qualitative research involves the researcher beginning with a large body of information and must, through inductive reasoning, sort and categorize it and gradually bring it down to a set of underlying themes (Leedy and Ormrod, 2013:150). The data was analysed using the Atlas.ti software. The analysis began with an open coding of the data by assigning codes to segments of the text. As suggested by Henning et al. (2004:132), this was followed by axial coding where 'the parts of the data identified and separated in open coding are put back together in new ways to make connections between categories or the codes.' Various aspects of scientific inquiry guided this process. The codes were grouped into code families, which to a large extent corresponded with specific scientific inquiry aspects within which the study is framed. The researcher and two colleagues (postgraduate students) sought to establish reliability in this process of coding and grouping codes into families by doing the coding independently.

3.4.2 Trustworthiness

For *qualitative research, validity* has a plethora of meanings, the reason being qualitative researchers are of the view that the term validity is not applicable to qualitative research, but at the same time, have realized the need for some kind of qualifying check or measure for their research. As a result, many researchers have developed their own concepts of validity and have often generated or adopted what they consider to be more appropriate terms, such as quality, rigour and trustworthiness (Davies & Dodd, 2002; Stenbacka, 2001). The traditional method of judging the rigour of a research inquiry is by the use of several of the following six strategies:

(a) prolonged engagement in the field,
(b) triangulation,
(c) peer debriefing and support,
(d) member checking,
(e) negative case analysis, or
(f) auditing (Guba & Lincoln, 1989; Padgett, 1998).

Researchers, who frame their studies in an interpretive model, think in terms of trustworthiness as opposed to the conventional criteria of internal and external validity, reliability, and objectivity (Lincoln & Guba, 2000).

While the term validity is an essential criterion for quality in quantitative paradigms, in qualitative paradigms the terms credibility, neutrality or conformability, consistency or dependability and applicability or transferability are the essential criteria for quality (Lincoln & Guba, 2000). Credibility in quantitative research depends on instrument construction, but in qualitative research, “the researcher is the instrument" (Patton, 2002, p. 14). Thus, it seems when quantitative researchers speak of research validity and reliability, they are usually referring to a research that is credible while the credibility of a qualitative research depends on the ability and effort of the researcher. Although reliability and validity are treated separately in quantitative studies, these terms are not viewed separately in qualitative research. Instead, terminology that encompasses both, such as credibility, transferability, and trustworthiness is used. In the same vein, Denzin and Lincoln (1994) are of the opinion that four factors namely credibility, conformability, dependability and transferability, should be considered in establishing the trustworthiness of findings from qualitative research.

Credibility refers to the confidence one can have in the truth of the findings and can be established by various methods (Golafshani, 2003). Three credibility methods are triangulation, member checking and negative case analysis. Triangulation is defined as “a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study” (Creswell & Miller, 2000, p. 126). Triangulation is a way of corroboration that allows the researcher to be more confident of the study’s conclusions. In this study, with respect to triangulation, data from multiple sources through multiple methods (i.e. interviews and open-ended questions), were employed. *Conformabilit*y refers to the quality of the results, in other words, the degree to which qualitative data and their interpretations can be authenticated. The techniques used for establishing credibility such as data triangulation, investigator triangulation, and member-checking are important for building conformability. According to Denzin & Lincoln (1994) *dependabilit*y refers to the stability of the findings over time and conformability to the internal coherence of the data in relation to the findings, interpretations, and recommendations. An audit trail can be used to accomplish dependability and conformability simultaneously (Lincoln & Guba, 1985; Padgett, 1998). The audit trail for this study included detailed notes regarding data collection, data analysis, and any modifications made. Transferability or applicability means, in essence, that other researchers can apply the findings of the study to their own. To provide for applicability the study presents the findings with "thick" descriptions of the participants, the data collection procedures, the analytic procedures, and the emergent patterns. The current study invested in these ways to improve and demonstrate validity.

3.4.3 Researcher's Role

The role of the researcher was to design the study, seek permission to adopt the VASI questionnaire from its authors (Lederman, Lederman, Bartos, Bartels, Meyer & Schwartz, 2013) (see Appendix C) and design the semi-structured interview schedule. The researcher administered the questionnaire to the participants, organised interviews, led interviews, and analysed data. Furthermore, the researcher was a non-participant observer who recorded phenomena as they unfolded while at the same time raising additional questions on learners' understandings about scientific inquiry, following hunches and moving deeper into the analysis of the phenomena (MacMillan and Schumacher, 2001).

3.5 ETHICAL CONSIDERATIONS

The researcher applied to the North-West University Human Research Ethics Committee (Non-medical) for ethical clearance to conduct the research. The research proposal, which outlines the procedures, clear information to the participants, informed consent forms and copies of all the instruments to be used accompanied the application. The application also included copies of relevant letters and associated forms for each of the parties involved in the study (see Appendix D). After the committee approved the conduct of this study, a Protocol number was allocated for the researcher to proceed (see Appendix E).

After being granted ethical clearance by the North-West University Human Research Ethics Committee (Non-medical), the researcher then applied to the North-West Department of Education (NWDE) for ethical clearance to conduct the research in schools under their jurisdiction. Again, the research proposal, which outlines the procedures, clear information to the participants, informed consent forms and copies of all the instruments to be used accompanied the application. Permission was granted by the North-West Department of Education (NWDE). Permission was also obtained from parents, the science teachers and the Principals of the schools for their learners to take part in this research. All the above-mentioned participants, together with the learners, were given full knowledge of the purpose, nature and duration of the study. To ensure anonymity, pseudonyms were used, for example, Learner 11 School B instead of real names (Kanari & Millar, 2004, p.753). The complete dissertation was also subjected to the Turnitin programme to check for plagiarism (see Turnitin report, Appendix F).

3.6 CHAPTER SUMMARY

In summary, this chapter gave the research methods of how the study was conducted. The open-ended VASI questionnaire was employed as the main instrument in the collection of data because of its advantage in identifying the views of learners about scientific inquiry. The researcher was also the main instrument of data collection as described in this chapter.

CHAPTER 4

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

This chapter reports on the results of the empirical investigation conducted to investigate the Grade 10 learners' understanding about scientific inquiry. The qualitative data gathered through the investigation are summarized and discussed in this chapter. First is the description of the sample followed by results from the questionnaire and interviews and ultimately the summary of the chapter.

4.2 DESCRIPTION OF THE SAMPLE

The analysis and interpretation of data was based on the response of the Grade 10 learners in two rural schools in the North-West Province of South Africa. The total number of the respondents was sixty-seven (67). The responses on the questionnaire were recorded and analysed. Six (6) learners, three from each school were interviewed. All interviews were audio-recorded and transcribed verbatim. Results from questionnaires and interviews are given below.

4.3 QUESTIONNAIRE AND INTERVIEW RESULTS

A total of sixty-seven (67) respondents were identified. Out of that total, all of the respondents completed the questionnaire. The questionnaire had a 100% return rate because it was administered in person by the researcher. The questionnaire sought to elicit knowledge on five broad areas, namely: nature of scientific investigations; all scientific investigations begin with a question; inquiry procedures can influence conclusions; difference between data and evidence; and inquiry procedures are guided by the question asked.

4.3.1 Nature of Scientific Investigations

The first question on the questionnaire is about the nature of scientific investigations. Analysis of learners' responses revealed that these responses could be categorised into four (4) themes which emerged from the data. These themes are:

(i) an *investigation must have hypothesis*,

(ii) a *scientific investigation must have various variables*,

(iii) *a scientific investigation follows only one method* and

(iv) *there is a difference between an investigation and an experiment*.

With regard to the first theme - an investigation must have a hypothesis, out of sixty-seven (67) respondents, 30 (45%) responded by saying that all investigations must have a hypothesis whilst 37 (55%) wrote that not all investigations have a hypothesis. The respondents who stated that all investigations must have a hypothesis argued that hypotheses guide the person conducting the investigation. They pushed the idea that working with a hypothesis enables one to be focused in proving or disapproving their intelligent guesses. An excerpt from Learner 3 School B is as follows: *Before one embarks on an investigation, s/he has to plan. However, part of the planning involves giving a hypothesis. A hypothesis is an intelligent guess. It enables one to suggest possible answers. This is important in scientific investigations like the ones we do at the school*. During interviewing, Learner 11 School A made the same point when asked why he thought that an investigation must have a hypothesis. He said: *A hypothesis is an intelligent guess which enables one to have an idea of what to expect*. However, 55% of the respondents thought otherwise. For example, Learner 7 from school B wrote: *Not all investigations should have a hypothesis. The important thing to have is an investigative question. Once equipped with an investigative question, one can still do an investigation successful* (sic). Learner 11 from school B reiterated the same point during interviewing. She said: *A hypothesis is not a pre-requisite when doing an investigation. What is important is to have an investigative question. The purpose of conducting an investigative question is to answer the investigative question not to confirm one's hypothesis*.

The second theme which emanated from participants' responses is that *scientific investigation must have various variables*. A total of 55 (82%) out of 67 respondents concurred that scientific investigations must have variables. Their understanding is that for an investigation to be done, one must plan the procedures. As part of this planning, one has to decide the variables s/he is going to measure. So without the variables, these respondents thought that there is no investigation. For example Learner 25 School A wrote: *No investigation can be conducted without one having set down to decide on the procedures. Whilst one is on this* *planning phase, s/he has to decide on what to measure. These are what are called variables*. In agreement, Learner 17 School B, attested to the fact that without variables, there is no scientific investigation. He said: *All investigations consist of variables to be measured. Without the variables there is no investigation*. However, 18% of the respondents did not agree. To them an investigation can still be done without variables. They argued that as long as one knows what quantities to measure, then an investigation can still be done. Learner 19 School A wrote: *If we are doing an investigation on heating and cooling curves for example, then we measure the temperature and time, which is an investigation. We do not need variables*. Interestingly, Learner 7 School B thinks along the same logic. During interviewing she said: *Let us say we are doing an investigation on Ohm's law. If we can measure Voltage and Current, then we will have done an investigation. Variables are not that necessary*.

The third theme which emanated from participants' responses on the nature of scientific investigations is that *scientific investigation follows only one method*. All 67 respondents wrote in their responses that there is only one method which scientific investigations follow. They argued the method is almost evident in all textbooks. They also said their teachers have told them there is only one method. Learner 4 School B wrote: *There is only one method which scientists follow when doing a scientific investigation and this is known as the scientific method*. Learner 22 School A wrote: *True, there is only one method: the scientific method*. During interviewing Learner 7 School B and Learner 11 School A said: *There is one method which involves the following steps: Title of investigation, investigative question, hypothesis, design, conducting the investigation, analysis of data and drawing conclusions and finally reporting the findings.* When further probed, both participants said their teachers told them so and the information is almost in all Physical Science textbooks.

The fourth and last theme which could be elicited from participant's responses is that there *is a difference between an investigation and an experiment*. Of the 67 respondents, 50 (75%) were convinced that there is no difference between an investigation and an experiment; to them they were one and the same thing. Learner 18 School B wrote: *From books, one can refer to experiments as scientific investigations, so experiments and investigations are one and the same thing.* Learner 7 School A wrote: *The terms scientific investigations and experiments can be used interchangeably. They mean exactly one and the same thing.* Similar reasoning was obtained during interviewing. Learner 17 School B said: *During experiments,* *exactly the same procedures are followed during scientific investigation. It therefore means that they are exactly one and the same thing.* However, 25% of the respondents did not agree. To them a scientific investigation is guided by a problem. It is conducted when one wants to find out or solve a nagging problem which can either be simple or complex. For example, Learner 5 School B wrote: *The two cannot be the same, investigations are complex and experiments are simple. It is just following some given steps*. Learner 20 School A was in agreement by saying: *One can do an experiment without much thought about it. Just like baking a cake. Once the ingredients are there one can mix them unconsciously. So one can do the same with an experiment, one can just follow the method without putting much thinking into it. However, one cannot do that with a scientific investigation; one will be solving a problem and has to decide on the variables and means of measuring them. The two are therefore different.*

4.3.2 SCIENTIFIC INVESTIGATIONS ALL BEGIN WITH A QUESTION

Twelve (12) out of sixty-seven (67) respondents (18%) said that not all scientific investigations begin outright with a question. These respondents alluded to the fact that without a question, an investigation can still be conducted. However, 55 (82%) of the respondents said all scientific investigations begin with a question. They had a strong belief and conviction on what a scientific investigation is. They believe that in order to know what to investigate one must ask a question. For example, one of the twelve (12) respondents who said scientific investigations do not commence with a question is Learner 6 from school A. She wrote: *Learners need to have some specific knowledge that has been moulded into some curious pattern or question. This is the practice followed in science investigations and in research in any area.* This is also one of the six (6) learners who were interviewed. During interviewing, she said: *Not all scientific investigations begin with a question but what needs to be identified first is the problem. Once a problem is identified, then questions can be raised later when the investigation is in progress.*

4.3.3 INQUIRY PROCEDURES CAN INFLUENCE THE CONCLUSIONS

Of the 67 respondents, 46 (69%) said that scientists use the *same question* and follow the *same procedures* to collect data, and would generally come to the *same conclusions*. For example, Learner 15 School B wrote: *The inquiry procedures should be the same for* *consistency purposes and this entails working with the same investigative question resulting in the same conclusions being obtained.* One of the six learners interviewed is Learner 3 from school B who concurred with Learner 15 from school B. He said: *Scientific investigations follow similar procedures for repeatability of results and as a result same conclusions are obtained*. However, 21 (31%) respondents said the scientists must not come to the same conclusion. Two respondents who fall in this category said: *There is no way similar conclusions can be obtained regardless of the fact that the procedures are the same* (Learner 1 school A and Learner 7 school B). Meanwhile, 43 (64%) of the respondents said that scientific investigations having the same question and different procedure would never come to the same conclusion. A response which falls in this category is that of Learner 14 school B who said: *There is no way scientists will come to the same conclusion having started with the same question but having used a different procedure* (sic). Interestingly, 24 respondents (36%) said scientists would come to the same conclusion having used different procedures though they would have started with the same question. During interviewing, Learner 20 school A said: *By having the same investigative question, it implies that the conclusions have to be the same. The procedures can differ but the conclusions will be the same*.

4.3.4 DIFFERENCE BETWEEN DATA AND EVIDENCE

All 67 respondents showed that they did not know the difference between data and evidence. The respondents could not differentiate between the two. The respondents believed data is the information collected during the investigation. Some of them wrote data are measurements, some wrote data are observations and others wrote data are findings from the same or different investigations. When asked to give the definition of evidence, they gave the same responses they had given about data though rephrased. For example, Learner 13 School A wrote: *Data are the observations one makes during an investigation and evidence are findings from the same or different experiment or investigation*. Learner 19 School B wrote: *Basically there is no difference between data and evidence; they are one and the same thing*. Learner 6 School B gave the same response during interviewing, said: *During an experiment or let us say an investigation, during the experimenting stage people make observations and collect findings, these can be named data or evidence.*

4.3.5 INQUIRY PROCEDURES ARE GUIDED BY THE QUESTION ASKED

Of the 67 respondents, 57 (85%) are of the opinion that the investigation question is the one that guides the inquiry procedures during investigations. In their responses, the line of thought which was cutting through the responses is based on the idea that the investigative question is framed first. Only then, can one now start to think about the inquiry procedures to be followed. This cohort of respondents linked their reasoning with the scientific method. They said from the scientific method, the investigative question is asked first and then the procedures follow. For example, Learner 10 School B wrote: *From the scientific method, what comes first is the investigative question, only then can one start to think of procedures which will answer the investigative question.* Learner 16 School A wrote*: The purpose of the procedures is to come up with steps which will try by all means possible to answer the investigative question. So I say, yes, it is true that inquiry procedures are guided by the question asked*. During interviews, Learner 17 School B reiterated the questionnaire responses from other respondents by saying: *It is clear from the scientific method that the investigative question comes first. So the purpose of the whole investigation is to answer the investigative question. However, this can only be done by setting out reasonable procedures. Hence it is true, inquiry procedures are guided by the question asked.*

Conversely, 15% of the respondents believe inquiry procedures are not guided by the question asked. To these respondents, there is no relationship between these two constructs. Learner 29 School A wrote: *Procedures do not necessarily need to be guided by the question asked. Most if not all of the experiments we do in school are to prove a law or a concept hence there is no need for an investigative question to guide the inquiry procedures.* During interviewing Learner 7 School B said: *There is no relationship or link between inquiry procedures and question asked. One can have an aim of an experiment, for example, to prove Ohms law. This experiment can be done without a question asked but as I have said there is an aim. So inquiry procedures to me are not guided by the question asked*. This group of students do not see the link between the inquiry procedures and the question asked.

4.4 DISCUSSION

4.4.1. Nature of scientific investigations

Four themes namely; an *investigation must have hypothesis, scientific investigation must have various variables, a scientific investigation follows only one method* and *there is a difference between an investigation and an experiment* emerged from the respondents. It is noteworthy to state at this moment that the results suggest a range of understandings that shows a continuum of participants' knowledge about scientific inquiry regarding this facet. Some of the views are naive yet some of the respondent's views are informed. By informed, this study refers to the views about scientific knowledge and the scientific process that are generally believed or held to be true by members of the science education community (McComas, 1998). The opposite is true for naive views. As some of the participants correctly stated, a hypothesis is defined as an intelligent guess to an investigative question. At Grade 10 level, the National Curriculum Statement (NCS) emphasizes that learners should be able to phrase their own research questions and in the same vein frame hypotheses to their investigative questions. With the advent of the new curriculum, the Curriculum Assessment Policy Statement (CAPS), this emphasis has been watered down due to more stress now on Prescribed and Recommended experiments. This study produced results which corroborate the findings of a great deal of the previous work in this field by Dudu (2013) with Grade 11 learners in the Gauteng province of South Africa.

Most of the participants also harboured informed views when it comes to the second theme, *scientific investigation must have various variables*. Even what those participants who portrayed naive views termed as quantities would translate to variables. Be it in an experiment or an investigation, variables are involved. A possible explanation for these informed views might be that when teachers are busy doing prescribed and recommended experiments with their learners as outlined by the curriculum, they might be putting emphasis on identification of variables such as dependent, independent and constant variables which is good. The third theme - *a scientific investigation follows only one method* - produced unexpected outcomes. All 67 participants portrayed naive views and held the idea that there is a "Scientific Method": a recipe-like step-by-step procedure that all scientists follow and that guarantees developing claims about nature. This finding is consistent with results from previous studies (Abd-El-Khalick, 2006; Dogan & Abd-El-Khalick, 2008; Liang, et al., 2006) and a possible source of the misconception might be the way scientific research has been reported in journals and books (McComas & Olson, 1998). The findings of this current study are consistent with those of other studies (Dudu, 2014; Abd-El-Khalick, 2001;2006) who found that South African Grade 11 learners and American College students also believed scientific investigations follow one method. However, scientists can make meaning of the natural world using a variety of methodologies. To Bell, et al. (2010), what many refer to as the *scientific method* (testing a hypothesis through controlling and manipulating variables) is really a basic description of how experiments are done.

The fourth theme which emerged under the nature of scientific investigation facet is - *there is a difference between an investigation and an experiment*. Most of the participants in this study held naive views about this theme. To them an experiment and an investigation are one and the same thing, which is not true. An investigation is observing or studying the natural world, without interference or manipulation, and an experiment is an investigation that involves variables (independent/manipulated and dependent/outcome) and establishes cause-and-effect relationships (Schwartz, 2007).

4.4.2 Scientific investigations all begin with a question

Most of the respondents held informed views when it comes to this aspect. To them all scientific investigations begin with a question which guides observations made during the investigative process. Although these results differ from some published studies (Lematla, 2012; Bybee, 2000), they are consistent with those of Dudu (2013). A small percentage of participants harboured naive views regarding this scientific inquiry facet. This group of participants alluded to the fact that without an investigative question, a scientific investigation can still go on as long as observations are well made. Regardless of the fact that observations bring interest that can help for an investigation to exist properly, a question has to exist as one of the ways of doing science. Thus science can be distinguished from just walking through this word and observing. If one is watching a soccer match, s/he is observing and that is not science. It is this very issue that is at the heart of students not being able to ask a valid scientific question. Specific knowledge has to be melded into some curious pattern or question. This is the practice followed in science investigations and in research in any area. There is no denying the importance of observing the world, but observing the world without something guiding your observations is not science (National Research Council, 2000). To Lederman et al. (2013), science in general begins with a question.

4.4.3 Inquiry procedures can influence the conclusion

The results from this study show that the majority of the participants (over two-thirds of the sample) hold naive views with regard to this aspect of scientific inquiry. Conversely, even the participants whose responses were not naive were also not clear about the effect procedures have on a conclusion of an investigation. This finding is in agreement with Bartels et al's (2012) findings which found that learners always have problems in establishing how procedures followed during an investigation affect the conclusion(s) of that investigation. Nevertheless, the procedure selected for a scientific investigation invariably influences the outcome. The operationalisation of variables, the methods of data collection, and how variables are measured and analyzed all influence the conclusions reached by the researcher. For instance, Lederman et al. (2013) illustrate this point with a common investigation in high school biology classes which examines the root cells of a plant to identify cells in various stages of mitosis. They allude that the procedures used by the student invariably influence the type of data they collect; therefore affecting the conclusions they may reach. Invariably and more generally, throughout the history of science technological advances have impacted the common practices of scientists, the results of their undertakings, and knowledge generated. Our understanding of the structure of the nucleus is just one example that shows our knowledge changing as a function of the investigatory procedures employed (Lederman, Abd-El-Khalick, Bell, & Schwartz (2002).

4.4.4 Difference between Data and Evidence

All the participants in the study showed that they hold naive views when it comes to the difference between data and evidence. In contrast to earlier findings from other studies (Abell & Lederman, 2007; Abd-El-Khalick, 2001, 2007; Lederman et al, 2013), there is no evidence in this study which points in the direction of participants knowing the difference between the two. Data are measurements, observations and findings from other studies that are collected as part of the investigation. Evidence, in contrast, is analysed data and an interpretation of the analysis. It is necessary that learners understand the distinction between data and evidence and can describe how the interpretation of data (i.e., the use of data as evidence) is a potential source of bias (NGSS, 2013). To clarify this point, Lederman et al. (2013) give the following an example. They say: Consider when palaeontologists unearth dinosaur bones. These bones are not found in a perfect skeleton. Indeed, the bones are not even found in complete pieces. Scientists must use what they already know about skeletons in conjunction with the data (the newly unearthed bones) to construct the skeleton, while also remaining aware of any potential inconsistencies with current knowledge. For learners to know the difference between data and evidence they must become aware of themselves as competent and confident learners and doers in the realms of science (NGSS, 2013).

4.4.5 Inquiry Procedures Are Guided by the Question Asked

Most of the participants harbour informed views regarding this aspect of scientific inquiry. A possible explanation for this might be that the participants linked this to the scientific method which they are exposed to in their science lessons. Indeed, inquiry procedures are guided by the question asked; the procedures implied for the experiment help to arrive at a correct answer. Furthermore, the method of investigation must be suitable for answering the question that is asked (Lederman, Antink, & Bartos, 2012). Meanwhile, a scientific investigation may be designed using different procedures to answer the same question: these invariably need to be capable of answering the question proposed.

4.5 SUMMARY

An analysis of the data derived from the empirical investigation conducted has been made. The data collected was analysed and represented by the number of learners who responded to the questionnaire used. Descriptive statistics was used to analyse participants’ responses. The chapter identified that learners harbour a variety of views regarding aspects of scientific inquiry considered by this study. Some of the views are naive whereas others are informed. Learners’ experiences played a big role in the views the participants portray. The next chapter focuses on recommendations and conclusions.

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.1 INTRODUCTION

This chapter presents a brief summary of the study, the findings on the literature review and analysis of empirical data and lastly, it makes recommendations based on the participants' views about scientific inquiry.

5.2 SUMMARY OF THE STUDY

The focus of this study was on Grade 10 learners' understandings about scientific inquiry. Chapter 1 gives a brief outline of the statement of the problem and rationale behind this study. In trying to find ways of improving learners' understandings about scientific inquiry, more concerted focus should be on learners' understandings of investigative questions. Chapter 2 reflects on the current and recent scope of the research studies and focuses on the South African science curriculum and practical work. The chapter further provides the definition of the concept of learners' understandings about scientific inquiry and discusses issues and challenges encountered by learners in scientific inquiry. Some areas that are highlighted include: an underlying conviction that engaging learners in authentic investigation activities could lead to their developing abilities to perform inquiry (Vhurumuku 2011; Wong and Hodson 2008). Doing investigations is one of the vehicles that could help the learners approach science with investigative mind-sets. Most problems that lead to learners' poor understandings of scientific inquiry continue to receive attention nationally and internationally hence ways and strategies of improving learners' understandings about scientific inquiry are emphasized. Chapter 3 focuses on the methods of research and the instruments used to gather data and the construction of the questionnaires and interview schedules for the participants. Chapter 4 presents findings, offers an analysis and interpretation of data as well as giving broad discussions of findings from the empirical investigation. The findings demonstrate the views harboured by Grade 10 learners regarding aspects of scientific inquiry which were under investigation in this study. The views about scientific inquiry (VASI) instrument were used to solicit these learners' understandings.

5.3 SUMMARY of FINDINGS

The findings of this research are discussed in conjunction with the purpose of the study in Chapter 1. This section therefore, focuses on the discussion of each finding in conjunction with the aims mentioned in Chapter 1 (cf 1.4).

5.3.1 Findings on aim 1: *To determine Grade 10 learners' understandings about specific characteristics of scientific inquiry.*

The literature revealed that the nature and scope of learners' knowledges about scientific inquiry consist of issues and challenges specifically with regard to scientific investigation. The findings revealed that participants hold different views and find it difficult to understand that: an investigation must have a hypothesis, a scientific investigation must have various variables, a scientific investigation follows only one method and there is a difference between an investigation and an experiment. The implication for this is the possibility that the respective learners might not be given opportunities in their schools to carry out several different kinds of investigation in order to have knowledge about scientific inquiry. If that is the case, then, learners are being denied a chance to engage in the practices of science which in turn might help them to understand how scientific knowledge is developed and practiced as it is implicitly laid out in the South African curriculum documents.

Regarding other characteristics of scientific inquiry, namely: scientific investigations beginning with a question; there being no single set or sequence of steps followed in all investigations; and inquiry procedures being guided by the question asked, learners' understandings reflected mixed constructs. Some evinced naive views whilst others articulated informed views. There are however, other aspects for which all participants showed completely naive views, for example, *there being no single set or sequence of steps followed in all investigations.* It could be assumed that such views emanate from certain curriculum practices, for instance, the emphasis by South African curriculum materials such as the CAPS document and prescribed books recommended by the Department of Education officials. Such curriculum materials put much emphasis on the Scientific Method and this is seen in almost all textbooks. It portrays the way in which science should be done and practiced regardless of the informed view that there is no such legitimation as one method of doing science.

5.3.2 Findings on aim 2: *To establish implications of these understandings in relation to the expected outcomes of the curriculum.*

Having established that participants (learners) from this study have mixed understandings about scientific inquiry, on a broader level, if this is the trend across the country, it implies that developing well-versed conceptions about scientific inquiry and practices should be a goal for the researchers (teachers and educationists) in the country. Scientific inquiry is typically taught in science classrooms by having learners conduct investigations or, in general, by "doing" inquiry, or by the immersion of learners into investigations (Sadler, Burgin, McKinney, & Ponjuane, 2010). This is assumed to implicitly and tacitly develop learners' knowledge about scientific inquiry. Given the understandings shown by learners in this study, this has important implications such as ensuring that learners in schools do the experiments prescribed by the (CAPS) curriculum. This would ensure that through conducting investigations or experiments, learners develop understandings about scientific inquiry.

However, to be able to do investigations, apparatus and chemicals must be available. This entails availability of laboratories in schools which would contribute positively to learners understanding scientific inquiry, in other words more qualified pedagogic approaches to science. The school communities and the Department of Education could be brought on board to ensure that learners have all the necessary equipment that they need in schools. The National Department of Basic Education could also initiate several opportunities for learners to improve their understanding in scientific inquiry.

5.4 RECOMMENDATIONS:

5.4.1 Recommendation 1

Special attention to be rendered to learners in order to improve the level of science

The Department of Basic Education should give attention to all schools by building science laboratories and providing all necessary equipment for the learners. This entails that learners should be doing experiments prescribed by the (CAPS) curriculum. This is because the teaching and research community has realized that inquiry can be considered as content, just as more familiar science subject matter (e.g., forces and motion, photosynthesis, oxidation-reduction reactions) (NRC, 2000; NGSS, 2013). Eventually, this might empower learners to make appropriate decisions essential for effective learning. By doing practicals, learners are enabled to understand science. The main goal of today's education on scientific inquiry further emphasises that reflection is essential if learners are to become aware of themselves as competent and confident learners and doers in the realms of science.

5.4.2 Recommendation 2

More attention should be paid to implementation of effective science projects in schools

Scientific inquiry must start from lower grades in order to help learners when they reach the higher grades. Some learners in Grade 10 currently do not know how to use laboratory equipment which is the most important component in doing science. Regardless of the fact that the Department of Basic Education has initiated and implemented projects like Sediba and Dinaledi, not all schools are involved. Even if some of these projects have their own strategies for choosing participating schools, at least information regarding the projects should be made available to all schools. Participation in such programmes at an early stage such as in primary schools might help develop understandings about scientific inquiry at those early stages.

5.5 Future studies

Future studies looking at how learners' understandings about scientific inquiry help in the improvement of science results might be explored, that is, if there is a relationship between understanding about scientific inquiry and achievement in science. Now that it has been found that learners in the two cases of this study demonstrated mostly naive views about scientific inquiry, studies could be conducted to gauge implementation of policy and its expectations. Learners' understandings were established and found to be mostly naive; research could be done on how best their understandings could be transformed into informed conceptualisations.

5.6 LIMITATIONS OF THE STUDY

The study is limited to two schools in the North-West Province and this befits the design as it follows a case study approach. This enabled the researcher to understand the nature, dynamics and complexity of learners' understandings about scientific inquiry at the selected schools. The nature of design limits the study to two schools in addition to financial and time constants if more schools had been sampled. Further research on a broader scale is therefore recommended.

5.7 CONCLUSION

In this concluding chapter, the major findings, conclusions, and recommendations of the study were summarized. Limitations of the study were also highlighted. This descriptive, study set out to investigate the Grade 10 learners' understandings about scientific inquiry. As the findings of the study show, sampled learners held mixed scientific inquiry understandings, most of them being on the naïve spectrum. The assumptions that by doing investigations, learners get to understand scientific inquiry might be true. It seems learners are not doing investigations and experiments in the *two cases* investigated.

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APPENDIX A

Views about Scientific Inquiry (VASI)

Class: _______________________________

Date: ________________________________

The following questions seek your views related to science and scientific investigations. There are no right or wrong answers.

Please answer each of the following questions. You can use all the space provided to answer a question and continue at the back of the pages if necessary.

1. A person interested in birds looked at hundreds of different types of birds that eat different types of food. He noticed that birds that eat similar types of food tended to have similar shaped beaks. For example, birds that eat hard-shelled nuts have short, strong beaks, and birds that eat insects have long, slim beaks. He wondered if the shape of a bird's beak was related to the type of food the bird eats and he began to collect data to answer that question. He concluded that there is a relationship between beak shape and the type of food birds eat.

   a. Do you consider this person's investigation to be scientific? Please explain why or why not.

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   b. Do you consider this person's investigation to be an experiment? Please explain why or why not.

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   c. Do you think that scientific investigations can follow more than one method?

If no, please explain why there is only one way to conduct a scientific investigation.

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If yes, please describe two investigations that follow different methods, and explain how the methods differ and how they could still be considered scientific.

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2. Two students are asked if scientific investigations must always begin with a scientific question. One of the students says "yes" while the other says "no". With whom do you agree and why?

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3. (a) If several scientists ask the ***same question*** and follow the ***same procedures*** to collect data, would they necessarily come to the *same conclusions*? Explain why or why not.

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(b) If several scientists ask the ***same question*** and follow ***different procedures*** to collect data, would they necessarily come to the same conclusions? Explain why or why not.

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4. Please explain if "data" and "evidence" are different from one another.

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5. Two teams of scientists are walking to their lab one day and they see a car pulled over with a flat tyre. They all wondered, “Are certain brands of tyres more likely to get flat?”

   Team A went back to the lab and tested various tyres’ performance on one type of road surface.

   Team B went back to the lab and tested one tyre brand on three types of road surfaces.

   Explain why one team’s procedure is better than the other one.

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APPENDIX B

INTERVIEW SCHEDULE

1. (a) Two students are asked if scientific investigations must always begin with a scientific question. One of the students says ‘yes’ while the other says ‘no’. With whom do you agree and why?
(b) If several scientists ask the same question and follow the same procedures to collect data, would they necessarily come to the same conclusions? Say, why or why not?

2. Two teams of scientists are walking to their lab one day and they saw a car pulled over with a flat tyre. They all wondered, “Are certain brands of tyres more likely to get flat?”

Team A went back to the lab and tested various tyres’ performance on one type of road surface.
Team B went back to the lab and tested one tyre brand on three types of road surfaces.
Explain why one team’s procedure is better than the other one.

APPENDIX C

LETTER OF PERMISSION FROM VASI AUTHORS

APPENDIX D

LETTERS USED TO APPLY FOR CONSENT

APPENDIX E

ETHICS CLEARANCE LETTER

APPENDIX F

TURNITIN REPORT