EXPLORING SCIENCE TEACHERS' VIEWS ABOUT THE NATURE OF SCIENCE AND HOW THESE VIEWS INFLUENCE THEIR CLASSROOM PRACTICES

by

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DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo, for the degree of Masters of Education (Science Education) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

CHUENE K.J (Mr) **Date**

DEDICATION

First and foremost, I would like to dedicate this dissertation to the woman at the heart of it all, the nucleus of my household, my beautiful and warm hearted wife Tumelo Sarah Chuene, I love you. To my late younger sister Tiisetso Patricia Chuene whose untainted trust in God and perseverance throughout her ailment became my mirror in frustrating time. To my unborn baby girl who is at the heart of my heart, Oarabile (Modimo Oarabile) Chuene, this should serve as a testament of hard work and long suffering to you baby girl.

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ABSTRACT

This study explored the science teachers' views about the nature of science and how these views influenced their classroom. The study was conducted in three public quantile-three schools in Dimamo Circuit of Capricorn District-Limpopo Province. It was a case study with twenty participants filling the open-ended questionnaire with four teachers who were observed and interviewed. The teachers were from the FET band with teaching experience ranging between one year and thirty years.

The essential research questions addressed in this study are, namely: What are science teachers' views about the nature of science? How do the science teachers' views about the nature of science influence their classroom practices?

Data were collected all the way through open-ended questionnaires, classroom observations and semi-structured interviews. The data collected were analysed through groups of themes. The four teachers observed and interviewed were grouped as one case.

It was found that most of the teachers held informed views about the nature of science from both data collected from the open-ended questionnaires and semi-structured interviews. There was a group of teachers whose views about the nature of science being tentative reflected uninformed views and the majority of teachers revealing uninformed views about the difference between scientific law and scientific theory. The teachers believed that theories develop into laws. There was also a majority of teachers who believed that scientific investigation follows only one universal route. It was also found that the same teachers who reflected informed views were not able to back them in their classroom practices. The majority of those teachers reflected no informed views in their classroom as such it was impossible to tell how their views influenced their classroom practices.

KEY WORDS

Nature of science, Classroom practice, Scientific law, Tentative, Scientific theory

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LIST OF ABBREVIATIONS

NOS	Nature of Science
DOE	Department of Education
DBE	Department of Basic Education
CAPS	Curriculum Assessment Policy Statement
AAAS	American Association for the Advancement of Science
ETA	Explicit Teaching Approach
RSA	Republic of South Africa
BED	Bachelor of Education
PGCE	Post Graduate Certificate in education
FET	Further Education and Training
OEQ	Open-Ended Questionnaire
SSI	Semi-Structure Interviews
Q 01	Question 01
T_1 -T_{20}	Teacher one to Teacher twenty

CHAPTER ONE: ORIENTATION OF THE STUDY

1.1 Introduction

This chapter presents the introduction, background and motivation behind the researcher's decision to embark on this study. This is followed by the research problem, which fully outlines the problem that prompted the study. This is then followed by the purpose of the study, which is also comprised of research questions, which helped guide the study.

1.2 Background and motivation

Science is very important in our lifetime, because it helps people understand the things happening in our everyday lives. Teachers are the major role players in helping learners understand science; because how they teach, science will influence their scientific knowledge starting from theory to practices. The way in which teachers teach the learners affects how they react towards science. In other words, the teaching methods and strategies implemented by teachers' impact on the learners' drive, enthusiasm and interest in science. This also affects how the learners' view and understand science. The researcher is of the view that a number of factors, which have a direct influence on how teachers teach science, influence the teachers' views about the nature of science.

The nature of science is a many-sided concept that includes aspects of history, sociology and philosophy of science (Bell, 2009). Nature of science refers to the viewpoints and values that are basic to the advancement of scientific knowledge (Kaya, 2012). The phrase ''Nature of Science'' (NOS) is often used by science teachers to refer to issues such as what science is, how it works, the epistemological and ontological foundations of science, how scientists function as a social group and how society influences and reacts to scientific endeavours (Clough & Olson, 2008).

The nature of science comprises the tentativeness of science, the objectivity and subjectivity, scientific laws and theories, the empirical evidence, the scientific methods, the observation and inference and lastly the creativity in science (Bell, 2009). Although the nature of science has been defined in numerous ways, it most commonly refers to the values and assumptions inherent to the development of scientific knowledge (Lederman & Zeidler, 1987). Furthermore, Bell, (2009) emphasised that the nature of science is a concept that defies an uncomplicated definition and it has been variously defined as science epistemology and characterises science as a way of knowing. Concisely, authors have different views in defining the nature of science; however, they all agree that the nature of science is the literacy of science or scientific literacy.

The acceptance and understanding of the nature of science by the community plays a very important role in the development of learners and the community at large. Research on challenges in the public understanding of the nature of science can clarify impediments and propose how teachers, media specialists, and scientists who communicate about their work might help address the acceptance and lack of understanding (Sinatra, Kienhues, & Hofer, 2014; Sinatra & Hofer, 2016). One of the first issues that need to be raised in the public understanding and acceptance of the nature of science is the need for improved scientific literacy (Sinatra & Hofer, 2016). This is because the only way for the community to come to understand and eventually accept the nature of science is through nature of science literacy and the major mediators are the science teachers. It is the responsibility of the science teachers to educate schools and communities to understand the aspects of the nature of science and to develop their scientific literacy, it is necessary that science teachers hold adequate views of the nature of science (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, Moutinho, Torres, Fernandes & Vasconcelos; 2015). This nature of science knowledge is elementary in a bid to teach the aspects of the nature of science through methodologies that support activities in which schools and communities develop knowledge (Akerson, Buzzelli & Donnelly, 2009; Moutinho *et al*, 2015). They again develop the understanding of scientific background, as well as catch on, how scientists study the natural world, all of these by science teachers (Akerson *et al*, 2009; Moutinho *et al,* 2015).

The relationship between understanding and explicit attitudes by the learners and the communities is also multifaceted. Understanding is associated with more support for obviously useful science (Ziman, 1991). The critical science literacy provides a compelling answer to the question that has troubled science communicators for decades: What do citizens really need to know about science? (Priest, 2013). The literacy of science amongst people needs consistent improvement as such every probable way should be engaged to advance the shift process of science, in the schools, in the media, or wherever (Ziman, 1991). The literacy of science by teachers remains a major contributing factor in eradicating science illiteracy amongst science teachers. This is because teachers' views toward the nature of science are often measured as an important aspect that shapes their teaching views, and these views is likely to be connected their classroom practice (Hammrich, 1997; Lederman, 1992; Tsai, 2002). It is therefore reasonably clear that it is the task of each scientifically cultured individual to combat the severe lack of knowledge of the most elementary scientific facts and theories that is found even among the most educated people (Ziman, 1991). In order for science teachers to achieve a discerning scientifically literate community, it is argued that they should support amplified complexity in conception of the intrinsic principles, views and assumptions supporting science, otherwise referred to as the nature of science (Lederman, 1992; Provost, Martin, Peacock, Lipp, Bath & Hannan, 2011).

The maturity of scientific literacy has emerged as a key goal of scientific education for a long period (Bybee, 1996; Provost *et al*, 2011). Therefore, the teachers' proper, matured understanding of the nature of science (NOS), and the degree to which how well they are able to relay the knowledge and understanding to the learners is fairly determined by their views about the nature of science. This is because teachers' views toward the nature of science are often measured as an important aspect that shapes their teaching views, and these views is likely to be connected their classroom practice (Hammrich, 1997; Lederman, 1992; Tsai, 2002). The teachers' views about the nature of science promotes and encourage effective classroom practice, because studies showed that teachers' views about the nature of science, to a certain extent, were consistent with their teaching (Brickhouse,1989; Hashweh, 1996; Tsai, 2002). Therefore, when the teachers' views about the nature of science are matured, they encourage a productive, effective and informed science classroom practice, which in turn encourages productive, effective and matured views of nature of science by the learners.

The science curriculum should contain certain aspects that bring about the development of proper and well-guided syllabus as to ensure that the science teachers deliver adequate and well-balanced science curriculum. Science curricula must include the understanding of scientific contents, laws, theories, methods and procedures used by scientists, as well as the knowledge of the way in which scientists build up and utilise scientific knowledge, and how they gather and interpret scientific data (Ryder, Leach, & Driver, 1999; Moutinho *et al*, 2015). Although these aspects of the nature of science should be taught in science lessons, some research studies demonstrate that the relationship between teachers' nature of science views and their classroom practice is multifaceted. There are also several variables that interfere with the insertion and practice of nature of science in classrooms, such as classroom management, concerns for learner abilities and motivation, institutional constraints, teaching experience and anxiety with the understanding of the nature of science (Abd-el-Khalick, 2002; Moutinho *et al*, 2015). Therefore, the science teachers' personal touch and empathy contributes to the learners' willingness and eagerness to learn and improve their views about the nature of science. The research points out that the knowledge of the nature of science' understanding of the construction of scientific knowledge and the forms of argumentation used by the scientists help learners in the learning of science content (Songer & Linn, 1991; McComas & Olson, 1998; Sangsa-ard, Thathong & Chapoo, 2014). This means that science teachers must be fully equipped with the aspects used by scientists for proper and effective science classroom practice.

The nature of science (NOS) is a portion of science education that continues to be given little consideration in the enacted curriculum of schools in many countries (Tan & Boo, 2003). In South Africa, the Physical Science Curriculum and Assessment Policy Statement (CAPS) (Physical Science) is not explicit on the nature of science. Thus, teachers fail to see that science promotes knowledge and skills in scientific inquiry and problem solving (Department of Basic Education, 2011). The catalyst for this research is the findings from research conducted by Lynch, Kurup, Webb and Bantwini (2003) which suggest that South African Eastern Cape teachers have little if any, formal experience to the nature of science. Therefore, this research will attempt to determine whether teachers who believe that science is merely a body of knowledge that accumulates daily, act as transmitters of knowledge and teachers who believe that science is constantly changing and improving, will act as facilitators of knowledge. Hence, this research will attempt to establish whether teachers subscribing to different views of science, use different teaching techniques and strategies in the classroom. This research will focus on:

a) Teachers' views about the nature of science, and

b) How these view on the nature of science influence their teaching practices.

1.3 Research problem

Current reforms in science education highlight teaching science for all, with the intention of widening scientific literacy. In this view, science instruction must go beyond simply teaching science as a body of knowledge (Bell, 2009). Consequently, the understanding of the nature of science is regarded as a fundamental and important component for the science course of study in growing a society that is scientifically literate (Akerson *et al*, 2008; Bell, Abd-El-Khalick & Lederman, 2000; Lederman, 2007).

The research problem of this study is that in South Africa, the current Physical Science policy document (CAPS) is not explicit on the nature of science. As a result, teachers seem to fail to see that science promotes knowledge and skills in scientific inquiry and problem solving (Department of Basic Education, 2011). For example, Dekkers and Mnisi (2003) conducted a study in Limpopo province and found that teachers believed in common myths about the nature of science, common myths such as hypotheses become theories that turn into scientific laws. In addition, Lynch, Kurup, Webb and Bantwini (2003) suggested that South African Eastern Cape teachers have little, if any, formal exposure to the nature of science. Thus, this research will attempt to determine whether teachers who believe that science is merely a body of knowledge that accumulates daily, act as transmitters of knowledge and teachers who believe that science constantly changing and improving, will act as facilitators of knowledge.

1.4 Purpose of the study and the research questions

The purpose of this study is to explore science teachers' views about the nature of science and to determine how these views influence their classroom practices.

The following research questions directed this study:

- ❖ What are science teachers' views about the nature of science?
- ❖ How do the science teachers' views about the nature of science influence their classroom practices?

1.5 Definitions of key terms

Definitions of terms that are consistently used in this study are listed below.

Tentative "refers to all scientific knowledge being subject to transform in light of new proof and new ways of thinking" (Bell, 2009).

Creativity "is defined as a phenomenon whereby something original and one way or another important is formed and the created item may not be indescribable such as scientific theory" (Amabile, 1998).

Imagination "is the creative ability to structure images, ideas and ambience in the mind from input of the senses such as seeing or hearing" (Byrne, 2005).

Nature of science "is a concept that includes aspects of history, sociology and philosophy of science, and has variously been defined as science epistemology" (Bell, 2009).

Scientific laws "is a statement based on repeated experimental observations that describes some aspects of the universe" (Honderich, 1995).

Scientific theory "is an explanation of some aspect of the natural world that can, in accordance with the scientific method, be repeatedly tested using a predefined protocol of observations and experiments" (Oxford English Dictionary, 1961).

1.6 Research design outline

In the use of case study approach, the research design for this study was rooted upon the use of open-ended questionnaire named Views of Nature of Science Questionnaire D+ (VNOS D+), classroom observations and as well as the semi-structured interviews (Abd-El-Khalick, Lederman, Bell & Schwartz, 2001). Research design is described as an original plan according to which data is gathered to investigate the research question in the most reasonable way and it is a general plan for conducting the entire study (de Vos, 2001).

This was a qualitative research, which adopted a case study approach. Case study was a relevant design for the study, for the reason that case studies are descriptive, detailed and they absorb studying a phenomenon in its real-life context, and most significantly, in nature case studies search to expose extensive descriptions of participants' lived experiences of, opinion about and judgment for a situation (Cohen, Manion & Morrison' 2007). The type of case study adopted in the study, initially was multiple case studies. According to (Yin, 2003) multiple case studies enables the researcher to explore differences within and between cases.

Twenty (20) Physical Science and Life Sciences teachers from the Dimamo circuit around Ga-Dikgale in Limpopo province were involved in this study. The teachers were requested to write their responses on the open-ended questionnaire D+ (VNOS D+) (Abd-El-Khalick, Lederman, Bell & Schwartz, 2001). The study used the VNOS D+ to help determine the teachers' views about the nature of science. Four (4) of the participants were later observed on three (3) lessons each to help determine how they reflected their views and how those views influence their classroom practices. The four (4) teachers were also interviewed individually. Further details are elaborated in chapter three (3) of the study.

1.7 Significance of the study

This study will provide new knowledge about the teachers' views on the nature of science and will benefit the following persons:

- ❖ Other science teachers. This research will help improve their classroom practices and transform their views on the nature of science.
- ❖ Subject advisers. This research will help subject advisors to identify discussion topics for subject meetings and how the nature of science in viewed in policy documents.
- ❖ Educational institutions and non-government organisations that focus on in-service teacher training and professional development of science teachers. This research will help these organisations to identify targeted areas for professional development or in-service training

1.8 Research report plan

Chapter one (1) provides an introduction of the study followed by the background of the study. In the chapter a mini-literature reviews provided together with information the study seeks to establish. The research problem of the study and the purpose of the study together consist of, the research questions. An outline of the chapters in the thesis is, provided in this chapter. The outline of the current and the chapter to follow is also given in the form of summary.

A detailed and relevant literature review to the study is discussed in chapter two (2). This begins with the introduction of the chapter, which is followed by a thorough discussion on what the nature of science is. In this chapter, studies done worldwide, in South Africa and in Limpopo Province are highlighted. The conceptual framework adopted in the study is elaborated on this chapter. The chapter also has a conclusion and summary linked to the next chapter.

Chapter three (3) discusses the methodology employed for the study and how it is going to respond to the research questions. This includes thorough discussions on the research design followed by sampling, population, and data collection that leads into the instruments used to collect data. This is then followed by the analysis of data collected, quality criteria followed by ethical considerations and summary of the chapter respectively.

In chapter four (4) data collected is presented in three stages. This begins with data collected from the open-ended questionnaires from the twenty (20) teachers. The second stage of data presentation is the data collected from the four (4) observed teachers who were later interviewed in the third stage of the data presentation. This is finally followed by the outline of the chapter and the chapter that followed in the form of summary.

The final chapter of this study presents the discussions of the findings of the study. These discussions and findings help outline the conclusions and recommendations.

1.9 Conclusion

This chapter presented the introduction to the background and the motivation behind the researcher's decision to embark on the study of this nature. This was followed by the research problem, which fully outlined the problem that prompted the study. Then followed by the purpose of the study, which also comprised of research questions that helped guide the study, research design outline, significance of the study and lastly followed by the research report plan.

The next chapter will address studies undertaken on the nature of science. It will further highlight on how the framework of study is outlined.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The previous chapter presented the introduction, background and the motivation behind the researcher's decision to embark on the study of this nature and reasons why this study is a qualitative research.

This chapter seeks to address studies undertaken on the nature of science. The chapter focuses on the following: Studies on the nature of science worldwide, in South Africa and in Limpopo Province, conceptions and the views of NOS by both teachers and learners, the effect of teachers' views and understanding of NOS in the classroom and many more. The chapter further elaborates on the conceptual framework of the study.

2.2 What is NOS?

Science is a systematic approach to studying the ordinary world, with fundamental questions such as how does the world operate? Furthermore, such questions are answered by means of observations, testing and interpretation through common sense (McLelland, 2006). These tenets are responsible in exposing science and its characteristics, in other words science and its nature, known as the nature of science (NOS). The nature of science is a comprehensive concept that defies uncomplicated definition. It is comprised of aspects of history, sociology, and philosophy of science, and has variously been explained as science epistemology, science as a way of knowing the description of scientific knowledge. In other words, the finest way to comprehend the nature of science is to first think about scientific literacy (Lederman, 1992; Bell, 2009). The understanding is you take the nature of science out of science; the science loses meaning and identity.

2.3 Studies on the nature of science worldwide

2.3.1 *The importance of understanding the nature of science*

The significance of understanding the nature of science, mechanism of the nature of science have been a prominent feature of science education reform for many years and are encouraged to develop a fully scientifically literate citizenry (American Association for the Advancement of Science, 1990, 1993; McCommas & Olson, 1998; National Research Council, 2013). Hence, one (1) of the major skills of being scientifically literate is said to be the ability to understand not only the basic scientific concepts, but also the nature and the development of science and scientific knowledge. Thus, it is apparent that understanding nature of science is key factor of the scientific literacy for individuals (Dogan & Abd-El-Khalick, 2008; Hacieminoglu, 2014). According to Govender and Zulu (2017) the products and applications of science are widely recognised by the universal community as it is accustomed and essential to one’s daily living, but the method in which science was established, is evolving and the methods used to obtain knowledge and skills are not entirely well known and understood by the universal community.

One (1) of the major goals of science education is to help teachers and learners develop sufficient comprehension about the nature of science (Tsai, 2002). This is because according to McComas and Olson (1998) qualitative analysis of science education principles papers from many countries disclose that there is soaring level of compliance about the views toward the nature of science to be shared with learners. Hence, research also indicates that science teachers must understand the nature of science in order to teach it and understanding that the nature of science is a precondition of science literacy (Lederman, 1992; Sumranwanich & Yuenyong, 2014; Chaiyabang & Thathong, 2014). Hammrich (1997) and Lederman (1992) who found that teachers’ views about the nature of science are frequently measured as an imperative feature that frames their teaching views, and these views may be related to classroom practices supported this. Although some researchers bear the idea that teachers' views about the nature of science unswervingly influence their instructive practices (Brickhouse, 1990; Gallagher, 1991), others do not agree about the idea, and believe that teachers' instructive practices are not related to their nature of science views (Lederman & Zeidler, 1987). In order to achieve the goal of understanding the nature of science and promote scientific literacy teachers need to obtain enough understanding of the nature of science (Govender & Zulu, 2017)

2.3.2 *The consistency of teachers' views about the nature of science*

The studies by Brickhouse (1989), Hashweh (1996) and Tsai (2002) suggest that teachers' views about the nature of science, to a certain point, were unswerving with their classroom practices. According to (Sangsa-ard, Thathong & Chapoo, 2014) to bring out teachers understanding of nature of science, many researchers have already utilised an assortment of methods and instruments in evaluating the teachers' understanding of the nature of science. Nonetheless, they continually showed that teachers hold poor understanding of the nature of science. A further study by Sangsa-ard *et al* (2014) revealed that teachers held a poor understanding of the nature of science and the mainstream of them held naive views as well as intermediate views. The study further established findings that found no teacher holding informed views about the nature of science.

The necessity for teachers to be acquainted with the nature of science in order to teach it is a key component. However, teachers without assistance will not at all time result in effective science classrooms that incorporate ideas about science (Burton, 2013; Abd-El-Khalick *et al*, 1998; Brickhouse, 1991; Hodson, 1985; Lederman; 2007). According to (Robinson, 1965) today's teachers are faced with more or less overwhelming capacity of materials purporting to supply information which will enable the learners to understand the nature of science and science.

2.3.3 *The process of teaching and learning in a science classroom*

The teachers need learners who are willing to learn and ready to go an extra mile for their benefit of learning science. This is because the understanding of the nature of science enables any learners to find out knowledge for themselves and apply such knowledge to become informed public (Sangsa-ard *et al*, 2014). Hence, the optimal situation for learners' understanding of the nature of science involves both the teacher's knowledge and the teacher's skill to connect aspects to classroom situations. That is why it is also essential for professional development on the nature of science to have goals that address feedback from learners' work (Burton, 2013).

This eventually leads to having people with desired understanding of how science works and have been presented as a central component to accomplish scientifically literate society (Bilican, Tekkaya & Cakiroglu, 2012).

Robinson (1965) argued that many articles in the professional literature suggest that it is the process of science, which is mainly significant in teaching science to a certain extent than the teaching of the concepts of science. Hence, there is nowadays a broad agreement that the teacher designs and implements instruction and how the learners recognise the discipline of science (Desautels & Larochelle, 2004). Sangsa, *et al* (2014) suggested that by teachers openly addressing the nature of science production and reconstruction of science ideas was made clear, and helped learners realise that a few of the ideas they held were once held by scientists. Sangsa *et al* (2014) further stressed that by emphasising the investigative nature of science and science as a means of eloquent, which suggests that curriculum is giving some sway to assisting learners to recognise the nature of science.

The nature of science (NOS) should be measured as a snip of science education (Vazquez-Alonso, Garcia-Carmona, Mannassero-Mas, & Bennassar-Roig, 2012). Bazghandi and Hamrah (2011) suggested that if the objective of teaching science is to expand scientific mentality in the learners, then as an alternative to transmission of scientific data, the learners accomplish more complex and complete understanding of the procedure of creation and maturity of science and are able to think and live to that mentality. However, Lederman, Kim and Ko (2012) argued that teachers' understanding of nature of science seems crucial, but not adequate, for efficiently translating their understanding into science teaching. Consequently, the way, in which a teacher understands science and the nature of science, greatly influence the learners' understanding of science. This was also confirmed in a study conducted by Waters-Adams (2007). The study focussed on teachers’ views on relationship between the understanding of nature of science and its practices. The author found that the teachers seemed to have self-confidence in their follow-on practices. This self - confidence occurred only when it accorded with elements of their deeply held beliefs including those relating to an understanding of the nature of science.

Science plays an important role in present and future society and the teachers are the transmitters of this knowledge. However, the challenge is that the teachers do not possess such knowledge; as such, they will not be fit to teach. Sangsa-ard *et al* (2014) confirmed this in a study, where the results indicated that the teachers' understanding of the nature of science was inadequate to teach the nature of science to their learners.

2.3.4 *The impact of understanding the nature of science for the development of scientific literacy*

The understanding of the nature of science is important if individuals are going to make responsible personal decisions and become effective local and global citizens (Sansa-ard *et al*, 2014). This was further emphasised in a study by Sangsa-ard and Thathong, (2014), where the results indicated that teachers' understanding of nature of science is necessary for science teachers to promote learners' understanding of the nature of science. Thus, in order to develop learners’ scientific literacy, it is required that science teachers hold adequate conceptions of nature of science. This conception should be through methodologies that encourage growth and understanding of scientific ideas. This is because the understanding of nature of science also enhances teachers’ varying views of learning and teaching science (Abd-El-Khalick, Bou Jaoude, Duschl, Lederman, Mamlok-Naaman & Hofstein; 2004, Ekerson, *et al*; 2009, Moutinho *et al*, 2015; Chaiyabang & Thathong, 2014). This is why the understanding of nature of science is suggested as an objective of learning science for basic education (Chaiyabang & Thathong, 2014). This was also long established in a study by Hacieminoglu (2014) where the study revealed that the integration of nature of science in the science lesson. The learners gained questioning skills, enhanced their knowledge of tentativeness, increased their self-effectiveness, and the thought about the inquiring of theories.

A question can be: ‘Do teachers even have an appropriate understanding of the nature of science?’ A study conducted by Waters-Adams (2007) revealed that the way of motivation runs originally from curriculum to selection of teaching approach, beliefs about classroom practices, and the views of the nature of science. This means that teachers are guided by what is explicit in the curriculum, from there how they approach their lessons and their views are the last things to consider. According to Sangsa-ard *et al* (2014) emphasising the investigative nature of science and science as a means of eloquent suggests that curriculum is providing some influence to assisting learners understand the nature of science. The study also suggested that teachers obtain self-confidence in their science practices. However, this happens only when quality exists between their views about their classroom practices, their perceptive of the nature of science, and their common beliefs about how they should be teaching learners. Research suggested that conceptual understanding in science is facilitated as soon as the science learnt is deemed appealing to the learner as well as appropriate to his or her everyday life (Coleman, Tears & Dempster, 2015). Clough and Olson (2012) and Sangsa-ard *et al* (2014) confirmed this, when they stressed that the successful nature of science instruction assist learners to understand science content. The authors further suggested that successful NOS assist learners to work from the assumptions that lie beneath scientific knowledge. Hence, it continued to help elevate the learners' interests in science and science classes thus improving inspiration to learn the science content. It is also important that elementary school teachers should not shun passing on the proper concepts of the nature of science to their primary school learners even at the elementary level (Chaiyabang & Thathong, 2014).

2.3.5 *The science teachers' pedagogical content knowledge for proper classroom practice*

According to (Bilican *et al,* 2012), teachers must have required pedagogical content knowledge (PCK) for teaching the nature of science. The PCK required included sufficient subject matter connected to the nature of science and knowledge of instructional techniques. This could be done through developing science teachers' comprehension of the nature of concepts and growing science teachers' teaching methods by using Explicit Teaching Approach (ETA) (Abd-El-Khalick, Bell and Lederman; 1998; Clough, 1998; Bell, Lederman & Abd-El-Khalick, 2000; Schwartz & Lederman, 2000). Science teachers' content knowledge can also be done through professional development program. Thus, numerous attempts have been and maintain to be undertaken to improve learners and science teachers' views of the nature of science (Akerson, Abd-El-Khalick & Lederman, 2000; Billeh & Hasan, 1975; Carey & Strauss, 1968; Haukoos & Penick, 1983; Jelinek 1998; Ogunniyi, 1983; Olstad, 1969; Shapiro, 1996; Solomon, Duveen & Scott, 1994). This was confirmed in a study by Chaiyabang and Thathong (2014) which found that after teachers attended the professional development program, their understanding of nature of science's and instruction had improved. The further results indicated that teachers' understanding was improved by attending the professional development program.

2.3.6 *Religion and the nature of science*

In a study on, an examination of elementary and early childhood pre-service teachers' nature of science views reflected results that indicated that the nature of science aspects are not easily understandable lectures. The study further outline that taking more science courses does not automatically close the gaps in learners' understanding of the nature of science (Kaya, 2012). The study further revealed that the current study showed that pre-service teachers have familiar misconceptions concerning the meanings of scientific concepts. The study also made an alarming discovery that the religious devotion might be influencing the teachers' views of the nature of science. As such science teachers need to be aware of this and they should assist learners in appreciating that science and religious are not against each other and one is not greater to the other (Kaya, 2012; Abd-El-Khalick & Akerson, 2004). According to Abd-El-Khalick and Akerson (2004), Science and religion are just two diverse sources of knowledge and learners who fail to tell apart between scientific and religious knowledge, it might be very complicated for them to embrace valid views about the nature of science. Govender and Fikeni (2016) confirm this in a study, where they found that teachers understood some scientific concepts of NOS yet they could not assimilate their content knowledge with all seven sets of the nature of science.

2.3.7 *The fundamentals of teaching the nature of science*

Science teachers also consider the notion of nature of science itself as tentative and dynamic as having changed throughout the development of science and systematic thinking about its nature and workings (Lederman, 1998; Akerson, Abd-El-Khalick & Lederman, 2000). That is why the idea of the nature of science is elementary and significant part of the knowledge base for classroom practices and learning science and it is probable that the nature of science is a global concept that frames a learners' total scientific knowledge (Hammrich, 1997). While Grossman (1989) agrees that research has established that teachers' personal views of the subject matter they teach exerts a commanding influence on their classroom practices. This meant that teachers' views about the nature of science are part of them and it is simultaneously incorporated within their teaching methods. This was confirmed when Hammrich (1997) emphasised that among fundamental principles shaping the knowledge of the teachers' views of science are the conceptions they hold about the nature of science or their views of science as a way of knowing. The teachers' beliefs have been claimed to influence their science teaching and learners' attitude towards science. It is consequently very important that teachers have sufficient understanding of the nature of science as well as ability to transmit that understanding into practice (Abell & Smith, 1994; Bilican e*t al*, 2012). However, the investigation of teachers' ability to transmit their nature of science understanding into practice and how that ability could be improved still remains open investigation (Lederman, 2007). This means that it is inadequate for teachers to only understand the nature of science. The teachers must also be able to relay such understanding to learners through teaching strategies.

Teachers must be relevant transmitters of nature of science to the learners. This was highlighted in a study, which revealed that teachers' informed views about the nature of science might be compulsory for teaching (Tan & Boo, 2003; Lederman, 1992). The study further revealed that the teachers' informed views is an adequate indicator of the teachers' abilities to conduct science lessons which were infused with history and the nature of science (Tan & Boo, 2003; Lederman, 1992). A study by Tsai (2006) also discovered that to a certain extent, teachers changed their views toward the nature of science when they are enrolled in the courses of science education. Thus, many of the teachers may have reconstructed and reinterpreted their views about the nature of science. A study found that in order to develop teachers' understanding and teaching of the nature of science. It is important to emphasise developing teachers' understanding in both nature of science concepts, other means such as taking extra science education courses and instruction (Chaiyabang & Thathong, 2014). This means teachers should have sufficient understandings or conceptions of various aspects of nature of science efficiently (Abd-El-Khalick & Lederman, 2000; Chaiyabang & Thathong, 2014; Akerson & Abd-El-Khalick, 2003).

2.3.8 *Lesson plans in a science classroom*

A study by Abd-El-Khalick (2005) found that teachers who get familiar with the nature of science and how it is developed are more flourishing in teaching science. Therefore, some of the more flourishing efforts in achieving nature of science outcomes have been the results of unequivocal instruction in which the teacher guides the learners in exploring specific aspects of the nature of science in the science lessons (Sumranwanich & Yuenyong, 2014; Khishfe & Abd-El-Khalick, 2002). To some degree, it was suggested that the lesson plan analysis regarding the nature of science might provide an understanding of teachers' decisions about classroom activities and assessment strategies of nature of science (Bilican *et al*, 2012). The lesson plan analysis in current study revealed that pre-service science teachers made a progress in their nature of science instructional planning as results of continuous classroom support. Hence, when adequate support is given through instructors' feedback, class discussions, and peer lesson plan presentations, all participants could make significant development concerning their nature of science instructional planning (Bilican *et al*, 2012; Akerson & Abd-El-Khalick, 2003). It was therefore further suggested by Bilican *et al* (2012) that lesson plans might be excellent indicator of what teachers know about how to teach nature of science and what they need to know.

The study on elementary teachers' views on the nature of science according to their academic levels revealed that student teachers could not expand their own views on the nature of science in their educational lives before they come to education faculty (Yalcin & Yalcin, 2011). This was confirmed in various studies that revealed that student teachers (pre-service teachers) in broad-spectrum and pre-service teachers did not hold adequate idea about the nature of science (Erdogan, 2004; Kahyaoglu, 2004; Yalcin & Yalcin, 2011). It was subsequently suggested that it is essential that the learners at every level expand their views on the nature of science. In this way for the candidates, acquiring the viewpoints of nature of science will become easier (Yalcin & Yalcin, 2011). Hence, in their study on elementary teaching learners, Gustafson & Rowell (1995) had identified that their learners' views about the nature of science were closely related to their beliefs about teaching and learning science. It was recommended that science teachers need to find and expand ways to assist pre-service teachers build up informed views on the nature of science (Akerson & Volrich, 2006). It was also suggested that in service teachers be motivated with intentions to teach the nature of science and interpret their views into classroom practice (Akerson & Volrich, 2006).

2.3.9 *Uniformed views of the nature of science by science teachers*

Many studies were under taken and findings revealed how inadequate the views of the teachers are about the nature of science. This was confirmed in a study on teaching the nature of science through inquiry in a three-year professional development program. The study conducted by Akerson and Hanuscin (2007) found that all the teachers in the study held insufficient views of the target fundamentals of the nature of science. The study also found that some of the teachers initially lacked the ability to even define the nature of science, and consequently a belief that it was important to teach. Tan and Boo (2003) also confirmed this in a study on assessing the nature of science views of Singaporean pre-service teachers. The study found that for the general part, the pre-service teachers' nature of science views was definitely nowhere near the level of complexity. The level of complexity required for an effective education of the nature of science and general scientific literacy to their general charges.

The teachers' inadequate views about the nature of science remain a challenge to be dealt with. This is because, according to Akerson and Abd-El-Khalick (2003) even internalizing the importance of and being encouraged to teach nature of science is not sufficient to guarantee that experienced teachers openly include nature of science in their instruction. It was accordingly suggested that the way teachers understand science to a great extent influence how the teachers design and implement instruction and how the learners recognise the discipline of science. In addition, the studies further revealed that teachers' orientations to learner- cantered instructional practices, is a key in teaching nature of science effectively and they are closely subjective to their beliefs about how learners learn (Desautels & Larochelle, 2004; Pajares, 1992). Therefore, in this case one can say views on the nature of science by the teachers are not influenced by the teaching experience, but their views and beliefs have far more reaching repercussions.

Many studies discovered that most elementary teachers are not science specialists and their lack of experience with science affects their knowledge of science content (Akerson & Hanuscin, 2007; Atwater, Gardener & Knight, 1991; Schoeneberger & Russell, 1986). Thus when the teachers' knowledge of science content is affected, what the teachers deliver in the classroom will contain many loopholes. This means that learners will leave the classroom to some degree not well informed. It was supposed that the teachers' understanding of the nature of science will advance their understanding of science content which will amplify the teachers' confidence and also develop their abilities to efficiently deliver science instruction (National Research Council, 1996). It is also important to bear in mind that simply understanding content and pedagogy is not sufficient, understanding how to teach particular science content in one's own context is critical (Akerson & Hanuscin, 2007).

2.3.10 *The conceptions and the views of science teachers about the nature of science*

The conception of nature of science as a communally constructed and validated has important implications for science education, in other words, one's innovation to facilitate teacher candidates' conception of the nature of science is to impart strategies into science methods courses which elicit, confront and challenge one's conception of the nature of science (Hammrich, 1997). It was outlined that the role of science teachers is to arbitrate the learners' understanding of the nature of science and assist learners make scientific sense of the way in which conceptions are generated (Hammrich, 1997). Teaching and learning about the nature of science in Thailand has been emphasised since 1975 by presenting in high school curriculum, particular objectives including the view that learners have an understanding of importance nature of science concepts as primary ideas in science (Sangsa-ard *et al*, 2014). Hammrich (1997) cautioned that if it was an established belief that the way teachers teach science is concurrent to the teachers' conception of the nature of science. Then teachers themselves are also candidates of the conception of the nature of science (Jain, Lim & Abdulla, 2013). This was because the teachers' conceptions are linked to how they learn science (Jain *et al,* 2013). Hence, the learning of science without having the correct conceptions of the nature of science is a flaw in science education. Such warrants awareness and this concern extent to the science teachers, as they are the vanguard advocates in imparting the right conception of nature of science (Jain *et al*, 2013).

In the United States, there was an introduction of cooperative controversy approach, which gives a launching pad for learning science. It gives an opportunity for teachers to come to an understanding that their conceptions of the nature of science affect how they learn science content and consequently influences their conceptions of teaching science (Hammrich, 1997). According to (Lederman,1992), the nature or difficulty of one's conception of the nature of science may be yet a further factor, which interacts with the already recognised numerous significant classroom variables. As such, numerous studies emphasised that for change to happen, teachers need to be both displeased with their current conceptions and see the advantages of the new conceptions (Gunstone, Slattery, Bair & Northfield, 1993; Hewson, Tabachnick, Zeichner & Lemberger, 1999). Although it was suggested that the relationship between teachers' views toward the nature of science and their teaching orientations received some challenges in the light (Tsai, 2002). Such challenges were because of vagueness of the relationship in an actual classroom setting, where it is believed may arise from multifaceted contexts of school environment (Tsai, 2002). This was because during the past eight decades, almost all scientists, science teachers and science education organizations have agreed on the objective of helping learners develop informed conceptions of the nature of science (Abd-El-Khalick, Bell & Lederman, 1998; Duschl, 1990; Meichtry, 1993).

The development of learners and teachers' conceptions of the nature of science has been a concern of science teachers for over thirty years (Lederman, Wade & Bell, 1998). In fact, the inclusion of the nature of science as a prominent instructional objective in the science curriculum can be traced back to the early 1900's (Lederman, Wade & Bell, 1998). However, in some countries the nature of science is given little attention or no attention at all. According to (Tan & Boo, 2003) the nature of science is an aspect of science education that continues to receive little attention in the enacted curriculum of Singapore schools. Although, there had been no detailed investigation, or study into the exact amount of attention paid to the nature of science's issues (Tan & Boo, 2003). A number of studies have indicated the level of nature of science understanding exhibited by the teachers to be very low (Tan & Boo, 2003; Boo & Toh, 1998). That is why teaching and learning about the nature of science has become a major goal of science teachers (Sangsa-ard *et al*, 2014). Therefore, the conceptions, on how the nature of science is perceived and viewed has major impact on how is understood.

Conception in nature of science is either a much larger issue as teachers might induce misconceptions in nature of the science learners under their care at the receiving end, directly or indirectly (Jain *et al*, 2013). According to (Sangsa-ard & Thathong, 2014) science teachers play an important role in the success or the failure of the learners' development of nature of science understanding, that is why efforts of in science education have included much discourse about the importance of enhancing learners' conceptions about the nature of science. Hence, Schwartz and Lederman (2002) suggested that for instructional management planning and instruction of the nature of science, teachers need to firstly understand the concepts of the nature of science before any learning intervention related to the nature of science take place. Sumranwanich and Yuenyong (2014) therefore confirmed this in a study on graduate learners' concepts of nature of science and attitudes towards teaching the nature of science. The study discovered that in general, studies show that it is difficult to teach science teachers to understand and implement the nature of science instruction.

According to Abell and Smith (1992), many science teachers misunderstand and pull the wool over the eyes in the nature of science and the authors measured this as a problem, because teachers' views of the nature of science can influence their learners' conceptions of science. Tobin and McRobbie (1997) confirmed this in their study on beliefs about the nature of science and the enacted science curriculum. The study revealed that the beliefs of the learners about teaching, learning and the nature of science are dependable with those of their teachers. In addition, the study found that learners' objectives are also constant with their teachers and teachers' views are always associated with their classroom practices. Sumranwanich and Yuenyong (2014) further added that this is possibly because the nature of science is often addressed from any real science context.

2.3.11 *The teachers' conceptions about the nature of science and curriculum*

The teachers' conceptions of the nature of science play a significant function in the performance of science curricular, and teachers will implement science curricular in a way that reflects their own view of the nature of science (Travis, 1994). According to Yakmaci, 1998; Yalcin and Yalcin (2011) studies on elementary teacher candidates about the nature of science concepts have shown that they had absent knowledge and misconceptions. However, studies revealed that through interventions it is possible, but complicated, for elementary teachers to expand informed conceptions of the aspects of the nature of science (Akerson, Abd-El-Khalick, & Lederman, 2000; Akerson, & Abd-El-Khalick, 2003). Hence, recent studies indicated that an open reflective approach joint with classroom modelling of lessons emphasising aspects of NOS is efficient for developing teachers' conceptions about the NOS (Lederman, 2000; Akerson, & Abd-El-Khalick, 2003).

Lederman *et al* (1998) argued that research on the nature of science over the last thirty years had provided at least couple of dependable findings, regardless of the instruments used in the investigations. However, studies revealed that teachers emerged to have insufficient conception about the nature of science and found that the relationship between teachers' conceptions of the nature of science and classroom practice is not clear (Lederman *et al*; 1998). The study also revealed that the relationship was mediated by a large collection of instructional and situational concerns. Even though work to improve and encourage teachers' conceptions about the nature of science achieved some accomplishment. The academic background variables of the research have not been considerably related to the teachers' conceptions of the nature of science (Lederman *et al*, 1998).

2.3.12 *The conceptions and the views of science learners about the nature of science*

A study on 37 grade 9 learners' conceptions of the nature of science was undertaken in Thailand. The research findings indicated that the majority of the learners had little knowledge and held naïve views of all tenets of the nature of science (Sangsa-ard *et al*, 2014). The study suggested further that the learners' understanding of the nature of science was insufficient, disjointed and it was essential for teachers to advance the learners' understanding of the nature of science (Sangsa-ard *et al*, 2014). Although

Lederman (1995) suggested that little attention to the nature of science is apparent in teachers' classroom practices. Interestingly the very same teachers cited deficient in confidence in their knowledge of the nature of science and incapability to teach nature of science as main causes for not including it in classroom practice. He further emphasised that these findings are quite similar to what was previously been found in research on elementary teachers' attention to the nature of science (Lederman; 1995).

The learners' perceptions regarding the nature of science mostly influenced by what they are fed in the classroom. The deficient knowledge of teachers regarding the nature of science evidently has an effect on learners (Sangsa-ard & Thathong, 2014). Science teachers play critical role in the achievement or failure of learners' development of nature of science understanding (Sangsa-ard & Thathong, 2014). However, discouragingly there appears to be more studies revealing that teachers hold insufficient knowledge of the nature of science. Lederman (2007) which found that science teachers do not hold sufficient or informed views of the nature of science established this in a study. Hence, a study by Mihladiz and Dogan (2014), of science teachers' views about the nature of science and the place of nature of science in science teaching found most of the teachers admitting that their nature of science knowledge is inadequate. Therefore, inadequate nature of science knowledge from the teachers is the insufficient nature of science knowledge imparted to the learners.

According to Akerson and Abd-El-Khalick (2003) the conceptions of in-service teachers who maintain support that allows them to emphasise the nature of science tenets in their classroom triggers them to develop and teach suitable nature of science to their learners. However, these conceptions could often be hard to preserve, because it is even developmentally complicated for learners to gain suitable nature of science views (Ackerson, Morrison, & McDuffie, 2006). Antagonistically Lederman (1995) suggested that given the strong evidence those teachers' views about the nature of science do not necessarily influence classroom practice. Then ways should be established to help facilitate the conversion of teachers' views about the nature of science into practice.

2.3.13 *The science teachers' attitudes about the nature of science*

The individuals' attitude towards the nature of science plays the most important role in its understanding. Sumranwanich and Yuenyong (2014) confirm this on a study of in-service teachers' concepts of nature of science and attitudes toward teaching it. The study revealed that the in-service teachers' open nature of science classroom practice endorsed them to reflect about the nature of science from their learning activities. Although it seemed that, they had difficulty conceptualising the overview of the nature of science. The study recommended that the teachers had positive attitudes toward teaching nature of science in aspects of tentativeness of scientific knowledge and relationship of different kinds of scientific knowledge. This proved that more nature of science instruction does not always improve one's understanding of the nature of science. Kaya (2012) uprooted this in a study on examining elementary and early childhood pre-service teachers' nature of science views. The study discovered that teachers held misconceptions concerning the nature of science and taking more science courses, even unequivocal instruction may not be sufficient for enhanced nature of science views. Such remains a gap that needs to be filled, because the understanding of NOS can help people comprehend values of science, restrictions of science and impacts of science and technology (Lederman, 1992; Sangsa-ard *et al*, 2014). Therefore, lack of sufficient knowledge about the nature of science place a negative impact on the literacy of science.

2.3.14 *The effects of textbooks on teachers about the nature of science in the classroom*

According to (Chaisri & Thathong, 2014), textbooks personify the curriculum and set priorities for classroom teachers. A study conducted by Lederman (1992) of the learners and teachers' conceptions of the nature of science found that given the dominant role played by textbooks. The initial analysis of science textbooks provided some data on how science is presented to secondary learners. It was therefore concluded that textbooks give little attention to the history and development of scientific ideas. The study further outlined that the textbooks embrace information that can be used for many years devoid of the realisation that scientific knowledge is tentative. Hence, science teachers think of textbooks as instructional resources that support the teachers in planning and delivering science instruction to meet local and national curricular standards (Chiappetta & Koballa, 2002). A study by Blanco and Niaz (1997) established that science textbooks influence teachers' thinking, which in turn affects learners' thinking. As such, the teachers' views and beliefs about the nature of science play no role. This means that teachers mostly follow what is in the textbooks and it seems they find it difficult to identify the shortcomings of the textbooks they use and this is not helping anyone in the science fraternity.

A study by Chaisri and Thathong (2014) on Thai Secondary Biology textbooks found that the textbooks had a little emphasis on the nature of science. This had a life changing effect on the learners, because the reality is such that textbooks determine learners' experiences with school science to a larger extend (Valverde, Bianchi, Schmidt, Wolf & Houang; 2002). There was also an analysis made and it suggested that the majority of these insufficient descriptions were concentrated on the aspects of the nature of science (Chaisri & Thathong; 2014). The study also found that the nature of science was not a consistent thread, let alone an essential or organising theme in the science textbooks, which were analysed. Chaisri and Thathong (2014) suggested all the science textbooks presented the idea that there is a universal and structured method in science. Such an insufficient description was supported by conventional depiction of scientists, and the textbook authors either abandoned the idea that imagination. Therefore, creativity permeates science or claim that the involvement of creative thinking and imagination is imperfect to certain stages in science. This means that authors of science textbooks play a very huge role in relaying the proper and precise information regarding the nature of science and it is important to allow creativity and imagination to prevail in a science classroom. Hence, the authors of the textbooks often appeared not to understand the processes well enough to explain them to learners and therefore presented various misleading and inadequate descriptions regarding science (Chaisri &Thathong, 2014).

2.3.15 *The effects of teachers' views and understanding of the nature of science in the classroom*

Gallagher (1991) argued in a study carried out on pre-service and in-service secondary science teachers, by emphasising that knowledge and beliefs about the philosophy of science affect classroom practices. Most teachers' views of the nature of science affect their classroom practices and Tsai (2002), whose study suggested that teachers' views of nature of science are influenced by their beliefs, confirms this. Although Gwimbi and Monk (2003) suggested that the classroom context and the teacher's attitude towards the philosophy of science is stronger than the feeling of concern with academic qualification. It reflects back to the notion that most teachers' views about the nature of science are always affected by their beliefs towards the nature of science despite their academic qualifications. Hence, a study was undertaken on pre-service science teachers' understanding and acceptance of evolution. The study further focused on the teachers' views on nature of science and self-ability in beliefs concerning teaching evolution. The study revealed that the naive views on NOS were found to be connected with stronger self-ability in beliefs for teaching evolution successfully (Akyol, Tekkaya, Sungur &Traynor, 2012). Study by Coleman *et al* (2015) suggested that the way that a teacher understands the nature of science would influence the way the teacher teaches the scientific concept of evolution. A study by Eick (2000), Rutledge, and Warden (2000) recommended that teachers who lack understanding of the nature of science have difficulties teaching evolution for scientific understanding.

On a different note, a study conducted by Ma (2009) with 25 Secondary Schools' science teachers from China about their understanding of the nature of science in relation to their conceptualisations of nature. The study found that almost all teachers demonstrated a scientifically informed view of nature. This suggested that their understanding of the nature of science had considerably created their conceptualisation of nature. Although teachers may have an understanding of the nature of science, it seems their beliefs always determine how their classroom practices will turn out. Teachers unavoidably communicate messages about science in the classroom. Moreover, when such messages are normally to be explicit, as such their ideas about science are likely to be reflected in their conversations with the learners (Zeidler & Lederman, 1989). This means such actions may have influence on the extent to which learners find science interesting, challenging and understandable. Hence, studies outlined that the knowledge of the nature of science, understanding of the structure of scientific knowledge and the forms of argumentation used by scientists helps learners in learning science content (Songer & Linn, 1991; McComas & Olson, 1998; Sangsa-ard & Thathong, 2014).

A study on teachers' ideas about the nature of science suggested that there is a need to accomplish more detailed descriptions of teachers' ideas about the nature of science. The study further highlighted that these teachers' ideas about the nature of science must be implied in action than paper and pencil instruments (Guerra-Ramos, 2011). The findings of the study were later critiqued in a study conducted by Alonso, Carmona, Mas and Roig (2012). The study was conducted on 774 in-service and pre-service Spanish science teachers. The study concentrated on their thinking about the nature of science and the relationships connecting science, technology, and society. This included a new methodological approach to the teachers' assessment from a broader viewpoint that included the relationships of science with technology and society was presented. However, a study suggested that research relating to teachers' views about the nature of science still has to address critical issues and develop conceptual and methodological approaches. This is important if its findings are to enlighten the design of strategies to help potential and practising teachers to develop their understanding of the world of science and strategies to communicate it successfully to learners (Guerra-Ramos, 2011). This is because nowadays the general belief is that teaching science should not be restricted to the spread of scientific facts. Instead should also aim at developing a scientific mentality in the learners (Bazghandi & Hamrah, 2011). Therefore, in order to develop learners' understanding of the nature of science it is significant to focus on equipping pre-service and in-service teachers with sufficient understanding of the nature of science (Akerson, Abd-El-Khalick & Lederman, 2000). That is because if teachers do not have sufficient understanding of NOS, they cannot conduct NOS views to learners even if the views are suitably addressed in the science textbooks and curricular (Akerson *et al*, 2000). Hence, the development of an appropriate understanding of the nature of science by teachers is a worldwide force in school science education that aims to expand learners' scientific literacy (Liang, Chen, Chen, Kaya, Adams, Macklin & Ebenezer, 2008).

The teachers are the mediators of learning, it is therefore very crucial that what they mediate or relay to the learners is scientifically acceptable and relevant. One of the elements that can contribute to the success of the in relaying scientific knowledge to the learners is that teachers need to know their learners' views about the nature of science. This is because they can arrange teaching to develop their learners' understanding of the nature of science (Abd-El-Khalick, 2002). That is why science reform documents advocate that the teachers give suitable instruction for learners to reach sufficient level of understanding of the nature of science (National Research Council, 1996; American Association for the Advancement of Science, 1993). Therefore, in order for these teachers to be able to deliver the necessary instruction, they themselves need to have informed views of the nature of science (Akerson *et al*, 2008).

2.4 Studies on the nature of science in South Africa except in Limpopo Province

2.4.1 *How science teachers' relay their views in a science classroom*

The recurrent goal for science education has been for science teachers to better understand the nature of science to communicate a valid representation of science to their learners (Ogunniyi, 1983, 2004, 2006; Abd-El-Khalick, 2005; Lederman *et al*, 1998; McComas, 2000). Therefore, the emphasis of the curriculum changes in the recent past in South Africa has been to encourage scientific literacy. In addition, a comparable focus on the development of scientific literacy in schools had been advocated elsewhere in the curriculum in the past (Department of Education, RSA, 2002, 2003; Department of Basic Education, 2011). As such in South Africa, curriculum improvement in school science has confirmed the importance that ought to be given to the nature of science in the teaching of school science subjects (Ramnarain & Padayachee, 2015). This is because the construct “nature of science" has been highly developed as an imperative educational outcome by various curricula worldwide. In fact, studies suggested that one would be hard pressed to find the expression arguing against its significance as a prized educational outcome (Ramnarain & Padayache, 2015; Lederman, 2007; Driver, Leach, Millar & Scott, 1996).

It was highlighted that for an accomplishment of scientific literacy, there is a necessity for sufficient comprehension of the nature of science as a requirement (Lederman, 1999; Schwartz & Lederman, 2002; Wang & Schmidt, 2001; Liang *et al*, 2008). Therefore, there is a greater need for teachers to understand the nature of science and this can be improved with professional development program. Kurup

(2014) confirmed this in the study on the relationship between science teachers' understandings of the nature of science and their classroom practices. The results of the study submitted that the teachers who received an open instruction in NOS displayed better understandings in some aspects of NOS compared with those who were not open to the elements of instruction. Hence, over the years' diverse approaches achieving changing levels of success have been adopted to develop teachers and learners' understandings of the nature of science. Although studies indicated that professional development programmes on explicit, reflective instruction of nature of science, that engages teachers in scientific inquiry (Akerson & Hanuscin, 2007; Saad & BouJaouda, 2012; Herman, Clough & Olson, 2013; Kurup, 2014).

A study by Coleman *et al* (2015) revealed that the student teachers had poorer understanding of evolution, but more significantly the nature of science. The findings of the study further suggested that the acceptance of evolution is independent of changes in conceptual understanding of evolution and independent of changes in beliefs about the nature of science. Coleman *et al* (2015) highlighted that as a developing country, South Africa strives to contend globally in numerous areas. As such, most significantly teacher education and knowledgeable science teachers should display an understanding of fundamental concepts of the nature of science. This is contrary to the study by Linneman, Lynch, Kurup, Webb and Bantwini (2003) in the Eastern Cape Province. The study indicated that science teachers do not hold sufficient understanding of the nature of science. Linneman *et al* (2003) further suggested that the latest South African Curriculum policies, science knowledge and understanding are very broad. Consequently, if the processes of science are to be engaged critically as reference for teaching styles and strategies, then the nature of science needs to be addressed. This is because even if teachers have the understanding of the nature of science it does not mean they know how to teach it. In addition, Kurup (2014) suggested that a teacher who has a complex understanding of the nature of science is not necessarily able to translate this knowledge into classroom practice.

Lederman (1999) concluded that the arbitration of nature of science understandings in a classroom is a body upon a teacher's acknowledgment of the nature of science as an important cognitive outcome in a lesson. The cognitive outcomes in a lesson play a very pivotal role in the lesson. This is because they are the ones that help a teacher determine as to what measure of teaching style and strategy to employ in order to bring about a successful lesson. This is because from the results of studies accumulated over the years show nature of science remains a difficult and a problematic construct to deal and presents many challenges for teachers (Linneman *et al*, 2003). Hence, at this stage one might be tempted to downgrade the nature of science to the "too hard to teach basket". However, for science teachers, the rise of science, the conduct of science, its influence on principles and priorities relating to social responsibilities are complex to address without reference to some understanding of the nature of science itself (Linneman *et al*, 2003). As a result, number of researchers in science education and the nature of science had found that the improvement of understanding the nature of science is a key element to archiving scientific literacy (Alters, 1997; Moss, 2001).

A study conducted by Coleman (2006) found that South African teachers have reservations teaching certain aspects or topics in science due to their naïve views and understanding of NOS. Therefore, when a teacher shows no interest in the topic that is taught, learners are likely to show no interest either as such they are likely to underperform. According to (Coleman *et al,* 2015), teachers who lack understanding of the fundamental nature of science may present topic to learners in an inaccessible manner, leaving room for misinterpretations and misconceptions. Hence, research suggests that conceptual understanding in science is facilitated when the science learnt is regarded interesting to the learner as well as relevant to his or her everyday life (Taylor, 2001). As a remedial action, Kurup and Webb (2011) suggested that in order to remedy the issue of naive views of nature of science by teachers. The various higher educational institutions in South Africa started introducing course components connected to history and philosophy of science in the teacher education programmes. This took place in both in-service and pre-service, to develop teachers' understanding of the nature of science. According to Dudu (2014) the results of studies have shown that teachers harboured naive views presented in general a picture that the majority of science teachers viewed scientific knowledge as permanent truth and had little, if any, formal exposure to the nature of science.

According to (Coleman *et al*, 2015) the difficulty teachers face with regard to the teaching of some scientific topics appears to be compounded by their underprivileged understanding of the nature of science. This is because Abd-El-Khalick (2001) confirmed that both the teachers and the learners' beliefs about the nature of science are inconsistent. This means that the way teachers understand the nature of science will have more influence on how they deliver their science lesson in the classroom. With that being the case, Lederman (1992) eventually cautioned that the teacher's teaching experience does not contribute to a teacher's understanding of the nature of science.

2.4.2 *The curriculum, the teachers and the nature of science*

For science teachers, the increase of science, the ways of science, its authority on values and priorities, and its relation to social responsibility are difficult to talk about without suggestion to some understanding of the nature of science itself (Dudu, 2014). According to (McComas, 2015), the nature of science (NOS) is frequently a neglected part of science teaching. Although it provides a very important background for learners, detailing how science and scientists work and how scientific knowledge is created, validated, and influenced. However, the nature of science is not explicit, but only implied in the specific aim number two of Physical Science CAPS documents. The implication only promotes knowledge and skills in scientific inquiry and problem solving (Department of Basic Education, 2011).

It is expected that FET band teachers will incorporate the nature of science in classroom practices. It is however, difficult for the FET teachers to incorporate the nature of science during their classroom practices. This is because the policy is not explicit about how these teachers should incorporate the nature of science during their classroom practices. An adequate understanding of the nature of science has become increasingly important for science teachers in the context of the recent curriculum revisions being implemented in grades R-9 in South African schools (Kurup, 2014). Loughran, Berry, Mulhall and Gunstone (2003) stated that there are views about the way in which science should be taught in schools. However, views will not be sufficient as long as they are not incorporated in a policy document that serves as a vehicle on what should be taught in a science classroom.

The poor science results in South Africa are influenced by science teachers' classroom practices and their classroom practices are determined by how they view the nature of science. Although some curriculum studies sought to improve learners' nature of science, but only focussing on the curriculum which has no influence on the learners' conception of the nature of science (Tamir & Jungwirth, 1972; Durkee, 1974). Textbooks help translate the intentions of the curriculum into classroom practice by reflecting goals of science learning, such as understanding the nature of science (Albach & Kelly, 1998). Furthermore, many researchers realised that the teacher beliefs, explanations and performances as part of the curricular were ignored (Hacieminoglu, 2014; Lederman, 2007).

It is common sense to suppose that what a teacher knows will influence what he or she does in the classroom (Waters-Adams, 2006). The "enacted" curriculum of science teachers may be at odds with their espoused beliefs about of the nature of science (Waters-Adams, 2006). What the teacher knows and what the teacher teaches are all affected by the views about the nature of science held by the teacher. Lederman (1992) suggested that the nature of science might be regarded as the cornerstone in the teaching of science subject. He further emphasised that it is for this reason that science curricular in many countries agree on the development of an adequate understanding of the nature of science.

2.5 Studies on the nature of science in Limpopo Province

2.5.1 *The limited studies of science teachers' views about the nature of science in Limpopo*

A study conducted by McCall (2008) revealed that South African teachers have more acceptable beliefs about the nature of science as well as other levels of scientific concepts. This was no exception in Limpopo Province where study by Mpeta, De Villiers and Fraser (2014) where the study explored the influence of the beliefs of learners in some secondary school in the Vhembe District and found that there is a moderate acceptance of science concepts. This study, however, contradicted the study by Peker, Comet and Kence (2010) where the study reflected the complete opposite in the same province. Dekkers and Mnisi (2003) established this when they conducted a study in Limpopo Province and they found that teachers believed in common myths about the nature of science. The common myths such hypothesis becomes theories that turn into laws. The teachers further reflected other myths such as scientific laws and other ideas are absolute as they have a significant impact on science teachers' everyday classroom practices. The study also indicated that science teachers do not possess sufficient understanding of the nature of science. In Limpopo province not many studies have been done on the nature of science thus very little is known regarding the teachers' views about the nature of science and how these views influence their classroom practices.

2.6 Conceptual framework

A decisive part of any analysis of information is the conceptual framework used to conduct the study (Ramnarain & Padayachee, 2015). The conceptual framework best suited for the study is the adapted framework, which was originally developed by Chiappetta, Fillman and Sethna (1991). The framework was used to analyse themes in studies of nature of science. It was chosen and found to be fitting for this study, because of its reliability and its extensive employment by a number of researchers (Abd-El-Khalick, 2002; Chiappetta & Fillman, 2007; Chiappetta *et al*, 1991). Although this framework is widely used to analyse textbooks, it was therefore adapted to fit and go with the proposed study. This framework addresses theme relevant to this study, hence it was chosen. It was adapted by adding one theme that complemented the missing aspects. The relevance of this framework to this study is in its nature of exploring views of the nature of science and how these views affect teachers' classroom practices.

According to (Ramnarain & Padayachee, 2015) this framework addresses four themes; however, one more theme was incorporated to help adapt the framework. These themes will help address what each instrument seeks to establish. That is to say: These themes are elaborated below.

<u>Science as a body of knowledge</u> (this theme reflects science as a body of knowledge such as the concepts, principles, laws, theories, models and facts). This is because science as a body of knowledge is empirically based, requires human imagination and creativity and it is never complete, except that it is subject to change (tentative), in other word scientific ideas change as new evidence dictates revision of older ideas

(Akerson *et al*, 2000). It is therefore of expected that teachers' views about the nature of science must reflect knowledge of such tenets. It was further highlighted that scientific knowledge is subjective, meaning that scientists' previous knowledge, training, experiences and expectations influence their work as such teachers must be aware of such in their views (Akerson *et al*, 2000). This included the understanding of what scientific principles and models are, as well as the difference between the scientific law and theory. This theme further expects teachers' views to reflect their ability to differentiate the difference between observation and inference. Observation refers to things that are reachable to the sense, while Inference refers to that which is not easily reached to the senses but manifests itself through its effects (Akerson *et al*, 2000; Water & Lee, 2008).

<u>Science as a way of thinking</u> (this theme reflects on the scientific thinking, reasoning and reflection of the teacher). Scientists interpret things according to what they know and this is reflected as scientific way of thinking (Akerson *et al*, 2000; Water & Le, 2008). This is what is expected of the teachers' reasoning in their views. Therefore, the teachers' cultures and backgrounds influence their interpretation, perceptions and conclusions (Akerson *et al*, 2000). This means that teachers' views in reasoning will be influenced by their cultures, backgrounds, interpretation, perceptions and conclusions us uninformed tenets will reflect unformed views by the teachers.

<u>The investigative nature of science</u>, (this theme reflects the active aspect of inquiry and learning). The ability for teachers to reflect views that a general and universal scientific method exists, this means that the teachers must reflect the knowledge that there is no common series of steps that is followed by research scientists or science teachers (McComas, 1998). It is also important that the teachers reflect views that says they know that evidence accumulated carefully will not result in sure knowledge, because all investigators collect and interpret empirical evidence as such the evidence needs to be tested (McComas, 1998).

<u>The creative nature of science</u> (this theme encourages the scientific innovative side of the teacher in the classroom). The ability for teacher to reflect on their classroom practice of science is more creative than just procedural (McComas, 1998). This is because in science there is no sole guaranteed method that can be accounted for the success of scientific tenets (McComas, 1998). This is where teachers need to be

creativity and not fully be dependent on textbooks. Thus the making of scientific knowledge involves human creativity in the sense of scientists and teachers coming up with explanations and theoretical entities thinking (Akerson *et al,* 2000; Water& Le, 2008).

The interaction of science, technology and society (this theme is the application of science and how technology affects humankind). The ability for teachers to be aware that science is a social enterprise practiced in a larger cultural surrounding, as such it affects and its affected by various cultural elements and technology is interacted amongst such surroundings thinking (Akerson *et al*, 2000). This means that the teachers need to be reflecting such knowledge.
All of the five themes will be used to address the two research questions.

2.7 Conclusion

This chapter addressed studies undertaken on the nature of science. The chapter started by focussing on the following: the nature of science researched globally or worldwide, and then followed by the studies on the nature of science in South Africa except in Limpopo Province and finally the studies on the nature of science in Limpopo Province. It further highlights on how the framework of study is outlined.

The next chapter discusses the research methodology employed in this research.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter focussed on relevant literature on NOS. This chapter introduces and addresses the research methodology employed in the research. The following themes in relation to research methodology are presented: research approach, the study design, the sample of the study, the data collection, the data analysis and the quality criteria of the study. That is why being flawless with regard to the research methodology is key and should reflect the general objectives of the research, which in turn frames the research questions underpinned (O'Brien, Harris, Beckman, Reed & Cook, 2014; Twining, Tsai, Nussbaum & Heller, 2017).

This is a qualitative study, which explored science teachers' views about the nature of science and how those views influence their classroom practices. Qualitative research approach was suitable for this study. As the researcher was interested in obtaining much deeper understanding of the teachers' views of the nature of science in their everyday classroom practices. In qualitative research approach, the researcher seeks for deeper truth and the aim is to study things in their natural settings (Greenhalgh & Taylor, 1997). Another characteristic that authenticates the suitability of qualitative research for this study is that, it is often exploratory in nature and its purpose is to explore and interpret (Maphutha, 2012).

3.2 Research design

Research design is described as an original plan according to which data is gathered to investigate the research question in the most reasonable way. It is a general plan for conducting the entire study (de Vos, 2001). Research design understandably links the research questions with the research conclusions via steps taken during data collection and data analysis (Baskarada, 2014; Twining *et al*, 2017).

This qualitative research adopted a case study approach for this research. Case study was a relevant design for this study, because case studies are descriptive, detailed and they absorb studying a phenomenon in its real-life context, and most significantly, in nature case studies search to expose extensive descriptions of participants' lived experiences of, opinion about and judgment for a situation (Cohen *et al*, 2007). The type of case study adopted in the study, initially was multiple case studies. According to Yin, (2003) multiple case studies enable the researcher to explore differences within and between cases. While Maphutha (2012) suggested that in multiple case studies, the one issue or concern is selected; however, multiple case studies to illustrate the issue are also selected. Case studies are common in interpretive tradition, focus being on human interpretation and meaning of which are human behaviour and the reasons behind it (Aanestad, 2006). However, the researcher ended up opting for single case study, where a group of four teachers from three different schools were used as one case. The four teachers were used as a case, because they work at the same circuit, same village with similar background such as the lack of science laboratory. The schools use the same primary schools as feeders. The study adopted interpretive category, which refers to the fact that the aim of the qualitative research is not to explain human behaviour in terms of universally valid laws or generalisation, but rather to understand and interpret the meanings and intentions that underlie everyday human action (de Vos, 2001).

3.3 Sampling and population

Sampling is a process of selecting a small segment of the population to symbolize the entire population while sample is a group on which data is obtained from (Fraenkel, Wallen & Hyun, 2012).

The research took place in high schools in Dimamo circuit of the Capricorn District in Limpopo province. The forty-three (43) science teachers (20 Life Science and 23 Physical Science teachers) in the circuit form the population of the study. However, twenty (20) purposefully chosen teachers of which ten (10) teach Life Sciences and the other ten (10) teach Physical Science (10 male and 10 female teachers) formed the sample for the study. All twenty (20) teachers in the sample were required to complete the open-ended questionnaire. The twenty (20) teachers were sampled, because they represented almost 50% of the population and this helped to address the reliability and authenticity of the study. A further four (4) (2 Life Sciences, 2 Physical Sciences) teachers were conveniently chosen from the sample of twenty (20) teachers for classroom observation and interviews. The four (4) conveniently chosen teachers were selected from three (3) different high schools in the circuit.

3.4 Data collection

For the solution of this study, as far as data collection tools were concerned, the researcher used three (3) phases to collect data which included open-ended questionnaire (Langkos, 2014). The questionnaire was then followed by classroom observation, which required the organised recording of events taking place in the classroom (Marshal, 2016). The third phase of data collection was undertaken through semi-structured interviews, which intended to classify participants' opinions regarding the study (Langkos, 2014. The three (3) phases are elaborated below.

3.4.1 *Open-ended questionnaire*

The twenty (20) participants filled an adapted version (Annexure A) of Views of Nature of Science Questionnaire D+ (VNOS D+) developed by Abd-El-Khalick, Lederman, Bell and Schwartz (2001). The instrument (Annexure A) was used to gain the teachers' views about the nature of science; hence, the questionnaire used was open-ended. The researcher's initial plan was to make an arrangement with the Physical Science and Life Sciences subject advisors to allow the questionnaire be administered to the twenty (20) participants during circuit subject meetings. The participants were to be taken through the questionnaire to help provide clarity where needed during the subject meeting. The circuit subject meetings were chosen to ensure that all completed questionnaires were collected from all the participating teachers. There were however, no Life Sciences or Physical Science subject meeting held and due to time constraints, the plan to collect data through subject meetings was abandoned. The researcher travelled from one school to the next to ensure that the questionnaire reached the relevant subject teachers.

The questionnaire consisted of ten main questions; however, the questionnaire was adapted by leaving out questions that were not relevant to the study. Therefore, the questions focused on were 1, 2, 3, 4a, 6, 7 and 9a-9d. The rest were not considered.

3.4.2 *Classroom observations*

Views cannot be unswervingly observed but must be inferred. Inferences about views require evaluation of what individuals say, aim and do (Pajares, 1992; Mapolelo, 2003). Therefore, four (4) teachers from the sample of twenty (20) were conveniently sampled for classroom observations. Each teacher was observed three (3) times. The initial plan was to employ two (2) instruments during observation, namely, observation schedule (Annexure B) and video recording. There was, however, a challenge with the observed teachers who felt uncomfortable with being recorded while teaching. Where human subjects are involved, researchers must gain informed consent and behave in an ethical manner, including show of respect for the rights of participants, (O'Brien *et al*., 2014; Elliott, Fischer & Rennie, 1999; Twining *et al*, 2017). Therefore, video recording of the teachers during science lessons were abandoned and only the observation schedule was used.

Classroom observation helped the researcher to address how teachers' views about the nature of science influence their classroom practices. In other words, the classroom observations aimed to address research question number two.

3.4.3 *Interviews*

According to Berry (1999) the advantages of using interviews to gather data is that they offer a chance to get hold of what is inside an individual's mind, and therefore it makes it possible to gauge what a person knows (knowledge and views). The four (4) teachers observed were interviewed using a semi-structured interview schedule (Annexure C) after the classroom observations were completed. The schedule was used to provide guide to the researcher so that the researcher does not deviate from the topic at hand. The schedule had some questions similar to the OEQ, this was done to determine the authenticity of the responses by the teachers on the OEQ. All interviews were audio taped. The purpose of the interviews was to gain clarity and insight into teachers' classroom practices and responses of the open- ended questionnaire.

3.5 Data analysis

Data analysis consists of exploring, categorising, tabulating, testing, or recombining evidence to draw empirically based findings (Yin, 2009; Twining *et al*, 2017). Therefore, data analysis is the process by which interpretations and inferences are made which might include the development of a theory or explanation. (O'Brien *et al*, 2014; Twining *et al*, 2017). A number of strategies were employed throughout the process of data analysis to address the trustworthiness of the results (Noble & Smith, 2015). The data collected from the adapted VNOS D+ open-ended questionnaire were coded. The coding method used was a method for qualitative research devised by Saldana (2008). The data gathered from the open-ended questionnaire, responses were grouped according to their similarities. The data was then grouped into five themes based on the questions on the questionnaire.

The data collected from the classroom observations (four teachers observed) was grouped into similarities and arranged into five themes highlighted in the conceptual framework found in chapter two of the study.

The interviews recorded on the audio recorder replayed to help transcribe them properly and authentically are found in annexure F, G, H and I. The responses were grouped according to their similarities. The data were further arranged into five themes outlined in the conceptual framework in chapter two of the study. The data was then summarised.

The data from the open-ended questionnaire, observations and interviews were compared to establish similarities, trends and differences. The data from the three sources were used to establish relations between teachers' views about the nature of science and how those views influenced their classroom practices.

3.6 Quality criteria

Trustworthiness of a research study is important in evaluating its worth, which involves establishing credibility, transferability, dependability and confirmability (Lincoln & Guba, 1985). The researcher took into consideration these quality criteria aspects of research by:

- ❖ Using of multiple data collection strategies in the study, which ensured credibility and transferability of the research.
- ❖ Observing body language and facial expressions during classroom observations and interviews, which ensured that there were no biases?
- ❖ Verifying with teachers the authenticity of the data collected. Ensuring the researcher was a non-participant observer during the classroom observation.

3.7 Ethical considerations

Ethical considerations are necessary when human beings are participants and the focus of this study was on education, which focuses primarily on human beings (Maphuta, 2012; McMillan & Schumacher, 2010). According to (Leedy & Ormrod, 2005) whenever human subjects are involved there should be informed consent, right of respondents' privacy, protection from harm and honesty with professional colleagues. Therefore, to ensure that ethics of the highest standards were adhered to in this research, the following considerations were followed:

- ❖ Teachers were assured of anonymity, confidentiality and privacy (Newman, 2000). A declaration form of confidentiality, anonymity and privacy was signed (Annexure N).
- ❖ Ethical clearance was obtained from the University of Limpopo and the Limpopo Department of Education (Annexure K).
- ❖ Teachers were informed that their participation was free and voluntary and therefore they were free to withdraw from the study had they wished to do so.
- ❖ Informed consent was obtained from all teachers that agreed to participate in the study (Annexure E).

3.8 Conclusion

This chapter focussed on the research methodology employed in the research. The following themes in relation to research methodology were presented: research approach, the study design, the sample of the study, the data collection, the data analysis and the quality criteria of the study. The next chapter will present the results and the interpretations of the data collected in this study.

CHAPTER FOUR: PRESENTATION OF FINDINGS

4.1 Introduction

The previous chapter focussed on the research design used in the study. This chapter presents the results of the data collected in this study. The data was collected using open-ended questionnaire, lesson observation and semi-structured interviews. The data from each of the instruments are presented separately and integrated in the discussions and interpretation in the next chapter.

Table1: Key words/codes used in the data presentation.

KEYS	MEANINGS
OEQ	Open-Ended Questionnaire
SSI	Semi-Structured Interview
Q 01	Question 01
T_1 -T_{20}	Teacher one to Teacher twenty
T_1 and T_2	The respond (views) of teacher one and teacher two combined due to similarities in their individual responses.

Table 2: Biographic data of the teachers who participated in the study

Teachers	Age	Gender	Highest Qualifications	Grade Teaching	Subject Teaching	Teaching Experience
T_1	Late 50s	Male	BED HONS and ACE	8 to 12	Physical Science, Natural Sciences And Technology	Thirty three years
T_2	Early 50s	Male	SPTD	10 to 11	Agricultural Sciences and Life Sciences	Twenty eight years
T_3	Early 40s	Male	BED HONS Education Management	10 to 12	Mathematics and Physical Science	Fifteen years
T_4	Late 40s	Male	PGCE	8 to 12	Physical Science and Mathematics	Twenty four years
T_5	Early 40s	Male	Did not indicate	10 to 12	Life Sciences and English	Twenty two years
T_6	Early 40s	Male	ACE	8 to 12	Mathematics, Physical Science and Technology	Sixteen years
T_7	Early 50s	Male	Did not indicate	8 to 12	Physical Science and Natural Sciences	Twenty eight years
T_8	Late 40s	Male	ACE	8 to 12	Mathematics, Physical Science and Natural Sciences	Ten years
T_9	Late 20s	Female	BED HONS	8 to 12	Physical Science and Mathematics	Six years
T_{10}	Early 50s	Female	BA	10 to 12	Life sciences and English	Twenty seven years
T_{11}	Early 50s	Female	BED HONS	9 to 12	Life Sciences and Natural Sciences	Twenty seven years
T_{12}	Late 40s	Female	BED HONS	8 to 12	Mathematics and Physical Science	Twenty three years
T_{13}	Early 50s	Female	ACE	8 to 12	Mathematics and Life Sciences	Twenty two years
T_{14}	Early 40s	Female	PGCE	8 to 12	Physical Science and Life Sciences	Ten years
T_{15}	Late 50s	Female	BA	8,9 and 12	Life Sciences and Natural Sciences	Thirty years
T_{16}	Late 40s	Female	STD	8, 10 to 12	Life Sciences and Natural Sciences	Eleven years
T_{17}	Mid 20s	Male	BED HONS	8 to12	Physical Science and Maths	Three years
T_{18}	Mid 20s	Female	PGCE	8 to11	Physical Science and Natural Sciences	One year
T_{19}	Early 50s	Male	BED HONS	9 to 11	Life Sciences and Natural Sciences	Twenty Seven years
T_{20}	Early 50s	Female	BED HONS	10 to 12	Life Sciences	Thirty years

4.2 Teachers' responses from Open Ended Questionnaire

The original VNOS D+ questionnaire consisted of ten questions. This questionnaire was amended to ensure that only questions pertinent to this study were used in the questionnaire given to teachers (Annexure A). The following questions from the original questionnaire were used: 1, 2, 3, 4a, 6, 7 and 9 (a–d). Therefore, all of the 20 participants' responses are presented on the first part of the data presentation. The responses (views) of teachers are presented as per questions in the open – ended questionnaire (OEQ) with teachers who gave the same responses being grouped together. The responses (views) of all twenty (20) teachers who completed the OEQ are listed below.

Q 01 WHAT IS SCIENCE?

T_1 and T_3: Science is the converted human effort to understand better the history of the natural world and how the natural world works.

T_2 and T_{16}: Science is the application of scientific enquiry through theories, models and laws to explain and predict events in the physical environment.

T_4 and T_{16}: Science is a system of acquiring knowledge using observation and experimentation to describe and explain natural phenomenon.

T_5: Science is an intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.

T_6, T_{13} and T_{14}: Science is the pursuit and application of knowledge and understanding of natural and social world following a systematic methodology based on evidence.

T_7: The study of kinematics and chemistry.

T_8: The study of the universe.

T_9: The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and the natural world through observation and experiment.

T_{10}: Science is the study of natural phenomenon.

T_{11}: An organised body of knowledge on any subject.

T_{12}: Science is a systematic enterprise that builds and organises knowledge in the form of a testable explanation and predictions.

T_{15}: Is a specified type of knowledge on any on a particular subject.

T_{17}: The study of natural phenomena.

T_{18}: Science is the study of behaviour of the physical and natural world through experiments, and observation and in the experiments there must be scientific materials used.

T_{19}: It is knowledge about the structure and behaviour of the natural and physical world based on facts that can be proved.

T_{20}: Science is a search to understand our natural and physical world through observation, testing and refining ideas.

The above responses demonstrate that fifteen (15) of the twenty (20) teachers have a good understanding of what science is. The other five (5) teachers gave very short and unclear responses to the question showing that they were unable to clearly articulate what science is.

Q 02 HOW IS SCIENCE DIFFERENT FROM THE OTHER SUBJECTS TAUGHT AT YOUR SCHOOL?

T_1: Science calls for in-depth thinking that demands a lot of time.

T_2: Science differs from other subjects in that it makes people aware of their environment and equips people with investigative skills relating to physical, chemical and biological phenomenon.

T_3: Science is a systematic enterprise that builds and organised knowledge in the form of testable explanations and predictions about the universe.

T_4: Science uses logic and rational thought in order to comprehend the natural world.

T_5: It is being treated as a golden subject.

T_6: It helps to satisfy the natural curiosity with which we are all born, example is why is the sky blue.

T_7: Science requires more experiments.

T_8 and T_{12}: Science is different from other subjects on the basis that it must be hands-on as often as feasible to illustrate concepts that might be difficult to explain to learners.

T_9: Science involves all the spheres of our day to day living.

T_{10} and T_{15}: Science is a very practical subject.

T_{11}: It is practical and it involves experimentations and observation.

T_{13}: Science relies more on testing ideas where evidence is gathered for analysis.

T_{14}: It uses logical thinking and it must be as hands-on as possible to illustrate concepts that may be difficult to explain.

T_{16}: Science is more hands on and help illustrates concepts that may be difficult to explain verbally or by reading text.

T_{17}: Science teaches us things about science and teaches us how to do scientific studies on our own.

T_{18}: Science deals with observable, variable; it has both theory and practical.

T_{19}: The knowledge production in science is an on-going endeavour and science knowledge changes over time as scientists improve their knowledge and understanding.

T_{20}: Science is more practical, relies on testing theories, experiments and it also deals with real life situations.

Five (5) teachers reflected similar views. These views reflected science as requiring logical thinking. They further outlined that science is hands-on and require in-depth thinking. There were also thirteen (13) teachers who shared similar views by outlining their views that science is practical and it helps equip people with investigative skills. The teachers further outlined that science relies on testing theories and its knowledge changes as the scientists' knowledge expand. Lastly, there were two (2) teachers with similar views and they reflected uninformed views, as they seemed to fail in substantiating the differences between science and other subjects.

Q 03 DO YOU THINK THE KNOWLEDGE PRODUCED BY SCIENTISTS MAY CHANGE IN THE FUTURE?

T_1: Science will change in future as it is expanding and not static and this change will improve for the better.

T_2: It can further be added and developed, because this knowledge is passed from one generation to the next.

T_3: Yes, scientists are constantly trying to make new discoveries to develop new concepts and theories.

T_4: Science discovers and creates things through tried and tested methods

T_5: Did not answer the question.

T_6: Did not answer the question.

T_7: Yes. knowledge may change in the future, because scientists research and discover new things.

T_8: Did not answer the question.

T_9: Yes, the knowledge may change in the future due to the change in the world structures and behaviour of the physical and the natural world.

T_{10}: No, the knowledge will not change, but it will only continue to be improved.

T_{11}: Science will change in the future, as it is static and not stable.

T_{12}: The knowledge will not change because it is tested and proven, hence the law of gravity.

T_{13}: No, it will not change but science will continue to surprise us with what it discovers and creates.

T_{14}: Yes, science knowledge can change in the future, because there are new tools that enable new structures of knowledge.

T_{15}: Yes, because scientists always conduct the research as such they discover new things.

T_{16}: As it is based on investigations and more researches are done to develop these theories.

T_{17}: Yes, science is tentative in its very own nature.

T_{18}: Yes, some knowledge, as new discoveries are made which sometimes alter the known phenomenon.

T_{19}: Scientific knowledge changes over time as scientists improve their knowledge and understanding as people change their views of the world around them.

T_{20}: The knowledge may change and be expanded by adding new discoveries, and as new tests are made.

Based on the views reflected by the teachers, there are three (3) teachers with similar views. The views are viewed as uninformed as the teacher argue that science knowledge does not change, because all scientific phenomena are proven and tested. There were, however, fourteen (14) teachers whose views suggested that they were informed as they stated that science knowledge does change, with one (1) teacher stating “scientific knowledge is tentative in nature". There was also a group of three (3) teachers whose views could not be reflected, as they did not provide the answer for the above question.

Q 04 HOW DO SCIENTISTS KNOW THAT DINOSAURS REALLY EXISTED?

T_1: Through written information which is acquired by continuous study and research.

T_2: Did not answer the question.

T_3: By studying the fossils.

T_4: By studying the fossils of the dinosaurs.

T_5: The best evidence is the fossils that are found preserved in the rocks.

T_6: By studying dinosaurs' bones.

T_7: By studying fossils.

T_8: They just read about them.

T_9: Through science books and fossils.

T_{10}: Through science fossils records.

T_{11}: Through the study of fossils and literature.

T_{12}: They found dinosaurs' fossil bones and completed their skeleton.

T_{13}: By finding dinosaurs fossilised bones and complete skeletons

T_{14}: The best evidence is the fossils that are preserved in the rocks.

T_{15}: They conducted research and came to conclusion.

T_{16}: Evidence used by scientists are fossils that were preserved in the sedimentary rocks, through reconstruction they can complete the dinosaurs.

T_{17}: They have used carbon-dating; fossils helped them to understand and know that the dinosaurs really existed.

T_{18}: There are fossils with dinosaurs' structures and that is solid enough to prove the existence.

T_{19}: By researching on fossils.

T_{20}: A fossil was discovered and researched.

Base on the views given by teachers, there are four (4) teachers whose views are not similar. These views are considered uninformed as none of them gave a scientific view. There was also one (1) teacher whose views could not be determined as the teacher failed to respond to the question. There was, However,, fifteen (15) teachers whose views evidently reflected similar and informed views. The teachers were able to state that scientists determine the existence of dinosaurs from fossils preserved from the sedimentary rocks.

Q 06 WHAT DO YOU THINK SCIENTIFIC MODEL IS?

T_1: A representation of reality for a thorough explanation and clear understanding.

T_2: Did not answer the question.

T_3: A scientific model is where scientists represent a particular phenomenon in the world using something else to represent it.

T_4: The atmosphere created by super computers.

T_5: It is a conceptual representation whose purpose is to explain and predict observed phenomenon.

T_6: It is investigation

T_7: Did not answer the question.

T_8: It is a picture that represents a particular object or matter.

T_9: It is a tool that is used in science to explain natural and physical phenomena in an understandable way.

T_{10}: Did not answer the question.

T_{11}: It is a simplified scientific description of a system or process.

T_{12}: It is a testable idea created by a human mind.

T_{13}: It is a representation of an idea that can be tested and created by a human mind.

T_{14}: A presentation of an idea, an object or even a process or a system that is used to describe and explain a phenomenon that cannot be experienced directly.

T_{15}: It is a model that is laid down according to the rules.

T_{16}: It is a human construct to help us better understand the real world systems that can be easily manipulated.

T_{19}: It is a conceptual representation whose purpose is to explain and predict observed phenomena.

T_{17}: A sequence of events/ processes that are used to get certain product at the end.

T_{18}: It is a testable idea created by a human mind that tells a story about what happens in nature.

T_{20}: It is a design used to present something.

The above views reflected by the twenty (20) teachers revealed that six (6) teachers' views are uninformed as they were not able to reflect the true knowledge of what a scientific model is. While there were three (3) teachers whose views could not be determined as they did not answer the question. There were, however, eleven (11) teachers whose responses reflected informed views.

Q 07 DO YOU THINK THAT SCIENTISTS USE THEIR IMAGINATION AND CREATIVITY WHEN THEY DO INVESTIGATIONS/ EXPERIMENTS?

T_1: They can use their imagination and creativity in drawing conclusions.

T_2: Did not answer the question.

T_3: They use creativity during data collection and final results.

T_4: Yes, because, being a good scientist involves continuous imagination and creativity in terms of looking at the results and being able to find what you are looking for in the data.

T_5: Yes, no reason.

T_6: Yes, a good scientist generally has a lot of creativity and imagination, which is mostly required during analysis of data.

T_7: No, because there are scientific rules that need to be followed. When conducting experiment or investigation, you must hypothesise, do the experiment and make conclusions from the findings.

T_8: They are using resources to verify what happened in the conclusion of the previous investigation performed by others.

T_9: No, because they follow scientific skills in conducting the investigations and experiments.

T_{10}: When conducting investigations, they use their imagination and creativity in order to obtain best results.

T_{11}: No, everything they do must be scientifically proven through investigations or experiments where they observe the behaviour and write findings from their research.

T_{12}: It takes a lot of imagination or creativity to even figure out what would be useful to look at and measure any scientific phenomenon.

T_{13}: No, because they rely on conclusions or findings from previous experiments by other scientists.

T_{14}: No, investigation itself is more about finding data that corroborates or contradicts the decisions made.

T_{15}: No, they must be practical, they cannot just imagine.

T_{16}: Yes, they use their imagination and creativity in planning, experimenting, interpreting and conclusion.

T_{17}: Yes, because reporting results, observation and drawing conclusion are parts of investigation that uses imagination and creativity.

T_{18}: They use creativity and imagination during data collection and data analysis.

T_{19}: They set a hypothesis which must be tested there through planning and repeated test they determine their findings without any imagination or creativity.

T_{20}: They use creativity and imagination in their planning, experimenting and observation in order to prove their case.

The twenty (20) teachers' responses reflect one (1) teacher whose response could not be determined as the teacher did not respond to the question. Another teacher agreed that scientists use creativity and imagination when conducting investigation but the teacher was unable to substantiate on the answer provided. There were also a group of six (6) teachers whose were not aligned to the notion that scientists use creativity and imaginations in conducting their investigations. There were, However,,, ten (10) teachers whose responses reflected that they hold informed views as they agreed with the notion that scientists use their creativity and imagination to conduct investigations.

Q 09 (a) PLEASE GIVE AN EXAMPLE OF SCIENTIFIC LAW AND OF A SCIENTIFIC THEORY

- ***SCIENTIFIC LAW***

T_1: Law is defined with no provision of example

T_2; T_6; T_{12} andT_{13}: Law of conservation of energy.

T_3; T_4; T_{14}; T_{19} and T_{20}: Mendel's law of segregation.

T_5; T_8; T_{11}; T_{16} and T_{18}: Newton's law of gravitational force.

T_7: Law is defined with no provision of example.

T_9: Law is defined with no provision of example.

T_{10}: Law is defined with no provision of example.

T_{15}: Law is defined with no provision of example.

T_{17}: Law is defined with no provision of example

- ***SCIENTIFIC THEORY***

T_1: Theory is defined with no provision of example.

T_2; T_6; T_{10}; T_{12} andT_{13}: Heliocentric theory.

T_3; T_4; T_{14}; T_{19} and T_{20}: Darwin's Theory of evolution.

T_5; T_8; T_{11}; T_{16} and T_{18}: Earth orbits around the sun and Kinetic molecular theory.

T_7: Theory is defined with no provision of example.

T_9: Theory is defined with no provision of example.

T_{15}: Theory is defined with no provision of example.

T_{17}: Theory is defined with no provision of example

The responses to the above question reflected mixed views. There were fourteen (14) teachers out of the twenty (20) who were able to give a correct example of a scientific law. On the other hand six (6) teachers who instead of giving an example of a scientific law, they gave a definition of a scientific law. I   response to the second part of the question, four (4) teachers provided the definition of a scientific law without citing an example while sixteen (16) teachers were able to list three (3) different scientific theories.

Q 09 (b) WHAT DIFFERENCES ARE THERE BETWEEN SCIENTIFIC LAW AND SCIETIFIC THEORY?

T_1: Scientific law has been experimented and findings have been researched, while theories are just statements that have not been proven.

T_2: Did not answer the question.

T_3: Scientific theory builds up or leads to scientific law.

T_4: Scientific law it can often be reduced to a mathematical statement and scientific theory seek to synthesise a body of evidence.

T_5: A scientific law is a statement based on repeated experimental observations while theory is series of statements about element observed.

T_6: Scientific theory is an in-depth description or explanation of the observed phenomenon and scientific law is just a statement about an observed phenomenon. They remain true until proven otherwise.

T_7: Did not answer the question.

T_8: Scientific theory leads to formation of scientific law.

T_9: Scientific law does not explain why the phenomenon exists or what causes it whereas the scientific theory explains major phenomena of nature.

T_{10}: Scientific law is a statement of fact designed and set by people, while theory is an idea that needs to be tested.

T_{11}: Scientific law is a statement of fact to the effect that a particular phenomenon always occurs if certain conditions are present. Scientific theory is an idea or set of ideas that is intended to explain something.

T_{12}: Scientific law can be referred as a starting point of an observed phenomenon, while scientific theory an explanation of how the phenomenon exists.

T_{13}: Scientific law is a statement based on repeated experimental observation that describes some aspects of the universe and scientific theory is a well-substantiated explanation of some aspects of the natural world that is repeatedly tested.

T_{14}: Scientific law is a statement based on repeated experiments and observations, while scientific theory is an explanation that has been tested over time.

T_{15}: Scientific laws are the stipulated rules from what have been read from the books and they been practised, whereas the scientific theory is not practised, but laid only verbally.

T_{16}: Scientific law states, identifies and describes relationships amongst observable phenomena, while scientific theory is an inferred explanation for observable phenomena.

T_{17}: A theory is comprised of statements that are yet to be proven and scientific law is a set of statements that have been proven true.

T_{18}: Law is a scientific theory that has been proven true and theory is not yet agreed upon, it is still on negotiations and other researches.

T_{19}: Scientific law is a description of an observed phenomenon and can be measured or observed to be true, while a scientific theory is a well-tested explanation and can only be assumed and accepted to be true.

T_{20}: Scientific theory leads to the formation of a scientific law.

Two (2) teachers did not respond the question in the questionnaire. The responses of five (5) out of eighteen (18) teachers whose responses were alarming as they stated that scientific theory leads to scientific law, such views are uninformed. There were, however, thirteen teachers whose responses reflected informed views, as they were able to give substantiated responses of differences between scientific law and scientific theory.

Q 09 (c) WHAT SIMILARITIES ARE THERE BETWEEN A SCIENTIFIC LAW AND SCIENTIFIC THEORY?

T_1: All of them end up reaching conclusion.

T_2: The question is not answered.

T_3: They express the same phenomenon.

T_4: They are both based on a tested hypothesis and support empirical evidence.

T_5: The question is not answered.

T_6: They both describe a phenomenon, which has already been observed.

T_7: Before both of them, an observation was done and conclusion was reached.

T_9: They both are tested hypothesis and support empirical formula.

T_{10}: Both follow certain rules and instructions.

T_{11}: Before both of them observation was made and a conclusion was formed.

T_{12}: They are both supported by a large body of experimental data and describe a phenomenon, which has already been observed.

T_{13}: They both have hypothesis.

T_{14}: They are both derived using scientific methods and rules.

T_{15}: Both the scientific law and scientific theory are derived from the studying and from researches.

T_{16}: Not yet tested scientific law and scientific theory are called hypothesis.

T_{17}: They are both comprised of statements that could be accepted or rejected through scientific experiments.

T_{18}: They are all trying to give facts based on science and there have been experiments performed on both.

T_{19}: Both of them are accepted in the scientific community.

T_{20}: Both of them need to be tested and proven scientifically.

The responses from above reflected teachers views whose views are informed as out of the twenty (20) teachers only two (2) teachers whose views could not be determined. This is because the two (2) teachers failed to give response to the question given. The eighteen (18) teachers were all able to substantiate their responses on the similarities between scientific laws and scientific theories.

Q 09 (d) WHAT DOES THE WORD ' HYPOTHESIS' MEAN?

T_1: A proposed explanation made based on limited evidence as a starting point for further investigation.

T_2: A statement about something that one tries to test.

T_3: Hypothesis is what you predict about an investigation in terms of your variables.

T_4: A Hypothesis is an educated guess based on observation.

T_5: Hypothesis is an idea or explanation that you then test through study and explanation.

T_6: Is an educated guess based on observation.

T_7: It is a prediction from experiments.

T_8: A prediction or guess that need to be investigated.

T_9: A statement that can be tested and be proven positive or negative.

T_{10}: An educated guess.

T_{11}: Statement of expected results.

T_{12}: A possible solution.

T_{13}: A supposition or proposed explanation made on a basis of limited evidence as a starting point for further investigation.

T_{14}: An idea or explanation that you test through study and experiment.

T_{15}: Hypothesis is a statement, which needs to be proven; you can assume it is true; you must do investigation from what you know.

T_{16}: A genuine guess or prediction.

T_{17}: A tentative guess that can either be accepted or rejected through experiments.

T_{18}: It is a proposed explanation based on reasoning without assumptions, based on the evidence as a starting point for further evidence.

T_{19}: A proposed idea or explanation that need to be tested through study and explanation.

T_{20}: An educated guess or a clever prediction.

Thirteen (13) of the twenty (20) teachers were able to link the term hypothesis with conducting an experiment or testing of a statement. The other seven (7) teachers had misconception of what a hypothesis is. Their representation is considered a myth (McComas, 1998).

4.3 Lesson observations

The second part of data presentation is Lesson Observations for four (4) educators namely T_{17}; T_{18}; T_{19} and T_{20}. This part of data presentation for lesson observations represents part one (1) of the case as this is a case study. This means that, the data gathered from four (4) teachers who were observed and is presented as one (1) case (part one). The data is presented starting with day one to day three (3) of the lesson observations.

4.3.1 Lesson Descriptions for teacher T_{17}

Teacher T_{17} Lesson 1

Grade	**:**	12
Subject	**:**	Physical Science
Topic	**:**	Chemical reactions (Acids & Bases).
Lesson Aims	**:**	Not outlined
Assessment	**:**	Class activity
Resources	**:**	Textbooks, chalks and board

Teaching and Learning activities

Chemical formulae are written on the board and the learners one (1) by one (1) are expected to determine which are conjugate acids and conjugate bases.

Brief description of the lesson

The teacher expected every learner to play a role and voice their views where necessary. The teaching strategy used was class discussion with the teacher facilitated where necessary.

Brief description of how the teacher got learners involved in the scientific processes

As the chemical formulae were written on the board, the learners were expected to determining which were conjugate bases and conjugate acids. The learners had to write their answers on the board where they were open for criticisms by their fellow learners. The learners appeared to be accepting of the criticisms by their fellow learners and it appeared as if it was the culture of the classroom.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher gave the learners examples of bases and acids with the washing liquid used in the kitchen as well as fizzy drinks found in the refrigerators. This led to the learners providing their own examples.

Overall comments and observations from the lesson

The lesson was learner centred where the teacher asked the learners questions to help identify what they know and do not know. The teacher gave examples of acids and bases that could be found in the kitchen and this led to learners giving examples such as lemon, sunlight liquid and vinegar. However, other learners were not able to tell the difference between acids and bases from the kitchen. The learners kept on giving examples of acids when the teacher asked for base examples. He encouraged learners to use testing agents and he requested examples of testing agents. The learners were able to give an example of Litmus paper and Bromothymol blue.

Table 3: Some specific observations on lesson 1 in T_{17}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction	X	
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson		X
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X

14	use a learning activity from the textbook		**X**
15	inquire about what the learner knows (prior knowledge on the topic)	**X**	
16	inform learners that theories, laws, etc. are subject to change		**X**
17	get learners to infer or draw conclusion from data obtained	**X**	
18	allow learners to ask question for clarity	**X**	
19	solely dependent on the textbook		**X**

Teacher T_{17} Lesson 2

Grade : 12
Subject : Physical Science
Topic : Chemical reactions (Acids & Bases).
Lesson Aims : Not outlined
Assessment : Class activity
Resources : Textbooks, chalks and board and sunlight dishwashing liquid

Teaching and Learning activities

The learners were able to determine the conjugate base and acids from the chemical formulae of the previous lesson. The learners are now expected to write down a chemical equation.

Brief description of the lesson

All the learners were required to ask questions where they did not understand so that the teacher could determine what they know. The teaching strategy employed by the teacher was class discussion, and the teacher facilitated where necessary. The teacher further employed question and answer as he used probing questions to check learners' understanding.

Brief description of how the teacher got learners involved in the scientific processes

The learners were given chemical formulae to determine which were conjugate bases or acid and from they were expected to write the chemical formula of the chemical equation.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher brought sunlight liquid to the classroom and encouraged learners to write the name of any chemical used as part of the ingredients of the dish washing liquid. The teacher further encouraged the learners to write the chemical symbols of the chemical ingredients.

Overall comments and observations from the lesson

The teacher wrote the incomplete chemical equation on the board where the learners balanced them, determined the products, balanced the equation and identified acids and base. Some learners were able to correctly distinguish acids from base on the board while others failed to do so. The learners who struggled where helped by their fellow classmates and the teacher facilitated.

Table 4: Some specific observations on lesson 2 in T_{17}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction	X	
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson		X
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook		X
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook		X

Teacher T_{17} Lesson 3

Grade	**:**	12
Subject	**:**	Physical Science
Topic	**:**	Chemical reactions (Acids & Bases).
Lesson Aims	**:**	Not outlined
Assessment	**:**	Class activity
Resources	**:**	Textbooks, chalks and board and vinegar

Teaching and Learning activities

In the past two days, the learners were able to determine conjugate bases and acids. The learners were further taught how to write products of the chemical reactions. The learners were expected to mathematically balance the chemical equations.

Brief description of the lesson

The teacher as in the previous two lessons expected all the learners to participate and voice their views where necessary. The teaching strategy applied was class discussion, and the teacher facilitated where necessary. Question and answer was used to probe learners' understanding of concepts.

Brief description of how the teacher got learners involved in the scientific processes

The learners were expected to write the chemical equations products in reactions given and thereafter balance them. The learners struggled to balance the equations until the teacher explained.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher brought vinegar in to the classroom and encouraged learners to write the name of any ingredient used as part of the ingredients of the vinegar. The teacher further encouraged the learners to write the chemical symbols of the chemical ingredients.

Overall comments and observations from the lesson

The lesson was informative as the teacher gave the learners the latitude to ask questions where they needed clarity. The teacher further allowed the learners to make mistakes. The pit fall of the lesson like any other lesson was the absence of lesson aims in the lesson plan. This is because it is difficult to determine whether the teacher achieved his lesson aims without stating them.

Table 5: Some specific observations on lesson 3 in T_{17}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction	X	
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson		X
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook		X
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook		X

4.3.2 Lesson Descriptions for teacher T_{18}

Teacher T_{18} Lesson 1

Grade	**:**	11
Subject	**:**	Physical Science
Topic	**:**	Waves, Sound and light (Geometrical Optics)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Homework
Resources	**:**	Textbooks, chalks and board

Teaching and Learning activities

The teacher gave the learners some notes by writing them on the board and the learners copied the notes.

Brief description of the lesson

The teaching strategy offered by the teacher was instruction, lecturing, question, and answer. This is because the teacher gave the learners the notes and after they copied the notes, she asked questions based on the notes.

Brief description of how the teacher got learners involved in the scientific processes

The teacher was not able to engage the learners, as the learners copied notes and answered questions by referring into the notes; as such, it was difficult to determine their level of understanding.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher was not able to contextualise the lesson or engage the learners in any activities related to the nature of science. This is because the learners hardly asked any question. This led to the lesson being all about referring to the notes provided by the teacher.

Overall comments and observations from the lesson

The lesson was discouraging, as the teacher failed to spark any curiosity amongst the learners. The learners only wrote the notes and answered questions through referring to the notes provided by the teacher. The teacher did, however, give the learners the homework.

Table 6: Some specific observations on lesson 1 in T_{18}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question		X
2	spark the learner curiosity or interest in his lesson introduction.		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity		X
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson		X
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)		X
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

Teacher T_{18} Lesson 2

Grade	**:**	11
Subject	**:**	Physical Science
Topic	**:**	Electrostatics (Electric fields and Coulomb's Law)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Class Activity
Resources	**:**	Textbooks, chalks and board

Teaching and Learning activities

The corrections were made to the homework given to the learners the previous day. The teacher wrote a formula before introducing Coulomb's Law and the learners were made to state the law using only the formula.

Brief description of the lesson

The teacher used diagnostic assessment on the learners by using probing questions. The learners answered and in some extent debated around the answers, they gave. Therefore, the teaching strategies employed were whole class discussion, question, and answer.

Brief description of how the teacher got learners involved in the scientific processes

The teacher did not engage learners in scientific processes except to them responding to questions written on the. The learners were then expected to use the formula provided to answer the questions.

Brief description of how the teacher engaged learners in activities related to the nature of science

There was no engagement of any activity related to the nature of science by the teacher. All the teacher did was to encourage the learners to refer to the notes they copied the previous day, which made the lesson uninteresting.

Overall comments and observations from the lesson

The lesson was question and answer based, where learners were expected to answered questions by referring to the notes given previously. The teacher struggled to engage learners into scientific processes and engaging learners with activities related to the nature of science due to lack of apparatus needed for the lesson. The only thing she did was to ask question to help determine whether the learners understood or not. The lesson was therefore not as productive for both the learners and the teacher.

Table 7: Some specific observations on lesson 2 in T_{18}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

Teacher T_{18} Lesson 3

Grade	**:**	11
Subject	**:**	Physical Science
Topic	**:**	Electric Circuits
Lesson Aims	**:**	Not outlined
Assessment	**:**	Oral and written assessments through question and answer, and class activity
Resources	**:**	Textbooks, chalks and board

Teaching and Learning activities

The teacher introduced the lesson by writing notes on the board that learners copied into their notebooks. She then drew circuit diagrams on the board for discussions with the class.

Brief description of the lesson

The lesson was a teacher driven lesson where the teacher employed a question answer method and whole class discussion strategies. Learners were not involved in a learning activity related to electric circuits but merely responded to questions posed by the teacher.

Brief description of how the teacher got learners involved in the scientific processes

The teacher introduced Ohm's law where the learners were encouraged to define the law using the formula V=IR. The learners were made to make R the subject of the formula and from there they were made to define it using proportionality. This was, however, a mathematical process.

Brief description of how the teacher engaged learners in activities related to the nature of science

Explanations by the teacher made it difficult for learners to understand the content on electric circuits being taught. The teacher did not engage the learners in any practical activities related to the nature of science.

Overall comments and observations from the lesson

Learners were given notes and circuit diagrams to copy from the chalkboard. The teacher asked learners if they knew what the drawing was, he further asked learners to identify the symbols that were found on the figure. The majority of the learners were able to identify the ammeter, the resistors, bulbs, closed and open switch and the battery. The teacher continued by introducing the formula that helped learners to calculate potential difference and current. She used the formula R = V/I to define the key terms of resistance, current and potential difference. In the later stage of the lesson, the teacher asked the learners about the SI units of the stated above phenomena.

Table 8: Some specific observations on lesson 3 in T_{18}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

4.3.3 Lesson Descriptions for teacher T_{19}

Teacher T_{19} Lesson 1

Grade	**:**	11
Subject	**:**	Life Sciences
Topic	**:**	Nutrition (Balanced Diet)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not provided
Resources	**:**	Textbooks, chalks and board

Teaching and Learning activities

The teacher reads from notes in the textbook and the learners read along with the teacher in unison. The learners share the textbooks, as the number of the textbooks does not complement the number of learners in the class.

Brief description of the lesson

The teacher asked the learners some questions, where the learners taking part debated and provided answers. Therefore, the teaching strategies employed were whole discussions and the question and answer method.

Brief description of how the teacher got learners involved in the scientific processes

There was no learning activity given to the learners, it is therefore difficult to determine whether there was anything done to engage the learners in the scientific processes.

Brief description of how the teacher engaged learners in activities related to the nature of science

The pure content focus of the lesson has answered that learner were not involved in any aspect of NOS. The teacher never really was able to discipline the learners when they made noise. Some learners were even singing in the classroom

Overall comments and observations from the lesson

The teacher hardly used the chalkboard. He employed question and answer as a teaching strategy. The strategy was not helpful as the learners made more noise in his presence. The teacher further read out of the textbook where learners read along with him. The teacher explained to learners where he felt there was a need. The lesson was mostly disorganised as he failed to spark the learners' curiosity and willingness to learn or pay attention.

Table 9: Some specific observations on lesson 1 in T_{19}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question		X
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document		X
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity		X
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways		X
9	allow learners sufficient time to fully explore the concepts of the lesson		X
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)		X
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

Teacher T_{19} Lesson 2

Grade	**:**	11
Subject	**:**	Life Sciences
Topic	**:**	Animal Nutrition (Over Nutrition)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not provided
Resources	**:**	Textbooks

Teaching and Learning activities

The teacher reads from notes in the textbook and the learners read along with the teacher in unison. The learners share the textbooks, as the number of the textbooks does not complement the number of learners in the class.

Brief description of the lesson

The teacher asked the learners some questions, where the learners taking part debated and provided answers. Therefore, the teaching strategies employed were whole discussions and the question and answer.

Brief description of how the teacher got learners involved in the scientific processes

There was no learning activity given to the learners, it's therefore difficult to determine as to whether there was anything done to engage the learners in the scientific processes

Brief description of how the teacher engaged learners in activities related to the nature of science

There was no activity given to the learners, it is therefore difficult to determine as to whether there was anything done to engage the learners in the nature of science.

Overall comments and observations from the lesson

The teacher used the same method of teaching where learners were expected to read along in their textbooks. The teacher had no teaching aids. The teacher further failed to engage learners in actual participation to participate. The teacher stood in front of the learners and never walked around the class.

Table 10: Some specific observations on lesson 2 in T_{19}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question		X
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document		X
5	design learning activities that relate to learners' everyday lives		X
6	design learning activities that allowed learners to use their imagination or creativity		X
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)		X
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

Teacher T_{19} Lesson 3

Grade	**:**	11
Subject	**:**	Life Sciences
Topic	**:**	Cellular Respiration
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not Provided
Resources	**:**	Textbooks

Teaching and Learning activities

The teacher reads from notes in the textbook and the learners read along with the teacher in unison. The learners share the textbooks, as the number of the textbooks does not complement the number of learners in the class.

Brief description of the lesson

The teacher asked the learners some questions, where the learners taking part debated and provided answers. Therefore the teaching strategies employed were whole discussions and the question and answer.

Brief description of how the teacher got learners involved in the scientific processes

There was no learning activity given to the learners, other than the corrections of the previous homework. It is therefore difficult to determine as to whether there was anything done to engage the learners in the scientific processes.

Brief description of how the teacher engaged learners in activities related to the nature of science

There was no learning activity given to the learners, it is therefore is difficult to determine as to whether there was anything done to engage the learners in the nature of science except for the teacher explaining to the learners.

Overall comments and observations from the lesson

The chapter taught was Cellular Respiration. The teacher and the learners made some corrections from the previous day. The teacher highlighted to the learners through lecturing that the process of respiration uses up oxygen and releases carbon while photosynthesis uses carbon dioxide and releases oxygen. The lesson was also ineffective as some of the learners made noise, as the teacher could not engage in the process of teaching and learning.

Table 11: Some specific observations on lesson 3 in T_{19}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question		X
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document		X
5	design learning activities that relate to learners' everyday lives		X
6	design learning activities that allowed learners to use their imagination or creativity		X
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways		X
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson		X
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)		X
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

4.3.4 Lesson Descriptions for teacher T_{20}

Teacher T_{20} Lesson 1

Grade	**:**	10
Subject	**:**	Life Sciences
Topic	**:**	Support in Animals (Skeleton)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not provided
Resources	**:**	Textbooks chalk and board

Teaching and Learning activities

The teacher gave the learners printed notes and as the teacher read out and the learners followed in unison.

Brief description of the lesson

The lesson was more teacher centred as the teacher read the notes and explained to the learners. The teacher further asked the learners some questions. Therefore, the teaching strategies employed during the lesson were instruction based, question, and answer.

Brief description of how the teacher got learners involved in the scientific processes

The teacher engaged the learners in the scientific processes by asking them to provide types of skeleton. The learners eventually did realise that there are endo and exoskeleton organisms. The learners, therefore, were expected to give or provide examples of animals or organisms with endoskeleton structures and exoskeleton structures. The learners further gave the examples of organisms and furthermore gave the type of skeletons they had.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher engaged the learners in the activities related to the nature of science, by giving the learners the types of worms and the type of skeletons. She further emphasised the type of nutrients the organisms had within them. The Mopani worms were given as the proper example.

Overall comments and observations from the lesson

The teacher gave the learners some printed notes, because there was a shortage of textbooks. The teacher explained to the learners as learners asked questions where they did not understand. The teacher further outlined to the learners on the different types of skeletons amongst the animals. The teacher further gave examples of animals without skeletons, animals such as earthworms. The lesson was more teacher centred as the teacher spent more time explaining to the learners without trying to figure out what the learners know. The teacher further lacked teaching aids such as the structure of an artificial skeleton.

Table 12: Some specific observations on lesson 1 in T_{20}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question		X
2	spark the learner curiosity or interest in his lesson introduction		X
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

Teacher T_{20} Lesson 2

Grade	**:**	10
Subject	**:**	Life Sciences
Topic	**:**	Environmental Studies (Eco-tourism)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not provided
Resources	**:**	Textbooks

Teaching and Learning activities

The teacher gave the learners printed notes and as the teacher read out and the learners followed in unison.

Brief description of the lesson

The teacher discussed with the learners about money generated from eco-tourism. Therefore, the teaching strategies employed in the lesson were whole class discussion, question, and answer.

Brief description of how the teacher got learners involved in the scientific processes

The teacher highlighted to the learners about the importance of looking after all kinds of animals. This is because if one type of animal gets extinct it will affect the ecosystem. She further gave an example of the rhino poaching and how it negatively affects the ecosystem.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher helped learners to realise that the way people live can negatively affect and impact on the environment. The teacher further highlighted that when the environment is negatively impacted, it can in return be dangerous to its inhabitants.

Overall comments and observations from the lesson

The teacher handed out some printed notes to the learners as they there were no enough textbooks. The teacher explained to the learners on how animal extinction affected the ecosystem. She further explained the importance of each animal. The teacher further outlined how each animal plays an important role in the ecosystem. The teacher further engaged the learners on how the environment changes and this force people to change on how they treat the environment. In most time of the lesson, the learners were quiet, as such, one could not tell whether they understand or not.

Table 13: Some specific observations on lesson 2 in T_{20}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction	X	
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook		X
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook		X

Teacher T_{20} Lesson 3

Grade	**:**	10
Subject	**:**	Life sciences
Topic	**:**	Environmental Studies (Eco-tourism)
Lesson Aims	**:**	Not outlined
Assessment	**:**	Not provided
Resources	**:**	Textbook, printed notes, chalk and board

Teaching and Learning activities

The teacher handed out some printed notes to the learners, explained and asked the learners some questions. The learners were expected to answer the questions by referring on notes provided.

Brief description of the lesson

The learners are asked questions, as the teacher encourages them to refer to the notes given. The teaching strategy offered by the teacher was question and answer.

Brief description of how the teacher got learners involved in the scientific processes

The teacher took the learners through the process of photosynthesis; she further explained to the learners how deforestation affects the ecosystem. She emphasised the lesson by outlining that the cutting down of trees decreases the availability of oxygen.

Brief description of how the teacher engaged learners in activities related to the nature of science

The teacher further made the learners aware of the indigenous medication and how it is as effective as the western medication. This led to the learners asking questions about animals' medication. One learner asked whether there was indigenous medication for the animals.

Overall comments and observations from the lesson

The teacher gave the learners some printed notes and made corrections from the previous lesson. The teacher introduced indigenous knowledge system where she made the learners aware that as much as people have doctors, animals also have doctors. She further explained that as much as people get sick, so are the animals.

Table 14: Some specific observations on lesson 3 in T_{20}'s class

No	Did the teacher:	Yes	No
1	start the lesson with a question	X	
2	spark the learner curiosity or interest in his lesson introduction	X	
3	conduct a lesson on a topic that is at an appropriate level for the learners	X	
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document	X	
5	design learning activities that relate to learners' everyday lives	X	
6	design learning activities that allowed learners to use their imagination or creativity	X	
7	provides learners with "hands-on" experience of science		X
8	allow learners to complete the learning activities in different ways	X	
9	allow learners sufficient time to fully explore the concepts of the lesson	X	
10	include the scientific process in the lesson	X	
11	use materials that are easy to obtain/use in the lesson	X	
12	allow learners to design their own investigation		X
13	give the learners a worksheet so that they follow it and conduct an experiment		X
14	use a learning activity from the textbook	X	
15	inquire about what the learner knows (prior knowledge on the topic)	X	
16	inform learners that theories, laws, etc. are subject to change		X
17	get learners to infer or draw conclusion from data obtained	X	
18	allow learners to ask question for clarity	X	
19	solely dependent on the textbook	X	

4.4 Presentation of data for interviews

The third and final data presentation is the Semi-Structured Interviews with the four (4) educators who were involved in Lesson Observations. This part of data (SSI) presentation for the data gathered from semi-structured interviews was presented as part two (2) of the case. This means that, the gathered data from four (4) semi-structured interviewed teachers were presented as part two (2) of the case study. The purpose of the interviews was to gain clarity and insight into teachers' classroom practices and addresses both research question one (1) and research question two (1). Abridged responses from the four (4) teachers who were interviewed are presented below. Detailed transcripts are found in annexures F - I.

Q 01: *In your own understanding, what is science and how does it differ from other subjects taught at your school?*

T_{17}: Science is a subject that deals with natural phenomena. Science is very practical and focuses more on experiments.

T_{18}: Science is just a study of the world and its interactions and the things that form the world.

T_{19}: Science is a subject that deals with natural phenomena and it differs from other subjects because is very practical and concrete.

T_{20}: Science is knowledge about the real life situation of living organisms. It differs from other subjects in a sense that the learners are aware of their surroundings.

The responses gathered from the four (4) teachers, reflect that they understood what science is. However, two (2) teachers out of the four (4) were able to state what really make science different from other subjects. The teachers stated that it is a practical subject that requires experiments. While one (1) teacher failed to state, the difference and the other teacher stated that science makes learners to be aware of their surroundings. The responses of the first two (2) teachers reflect informed views while the other two (2) teachers' responses reflected that the teachers have not been able to be fully clear about their responses on determining how different science is from the other subjects

Q 02: ***In your view what is an experiment?***

T_{17}: An experiment is a piece of task where learners together with the teacher will go to the laboratory at school and they will be having apparatus, which they will use to perform an experiment in verification of certain principles.

T_{18}: An experiment is some sort of a scientific test where learners together with the educator will go to a laboratory, whereby you practically want to prove theory through test.

T_{19}: An experiment is something used to prove scientific statements whether they are true or false by means of observing, touching and smelling

T_{20}: Experiment is a way in which one is trying to get the reality of the said statement. In order to prove whether the statement said is right or wrong one will have to make an experiment where we will have to observe. In other words, experiments are used to prove particular scientific statements whether they are true or false.

The four (4) teachers' responses reflected informed views of what an experiment is. Their responses are different, however, as they, all stated that an experiment is used to determine the authenticity of a phenomenon by means of observation, touching and smelling.

Q 03: ***How do the presences or absence of experiments in your lesson affect your lessons?***

T_{17}: The absence of experiments in my science lessons always affects the understanding of the learners.

T_{18}: I believe the presence of experiments in a lesson makes it easy for the learners to understand what the teacher is talking about.

T_{19}: Normally the presence of experiments helps people to understand better, because if they see things, things that are tangible.

T_{20}: The presence of experiments in a lesson makes it easy for the learners to understand what the teacher is talking about better. Through observing, touch and interact with things.

The four (4) teachers' responses on the question reflected similar views on the importance of experiments in their classrooms. The teachers' views reflected are similar as they all say the presence of experiments in their classrooms make it easier for their learners to understand when they are teaching. The absence of experiments in their classroom affects their science lessons negatively.

Q 04: ***Does the development of scientific knowledge require experiments? Explain.***

T_{17}: Yes, the development of scientific knowledge requires experiments, because we need facts and quality results that will contribute to the development of science.

T_{18}: Yes, the development of scientific knowledge does require experiments, because everybody holds a certain understanding of science and we cannot just bring ideas and approve them without testing their authenticity through experiments.

T_{19}: Yes, that is why our laboratory should have some of these apparatus that we use in that way it will instil some of the skills in the learners.

T_{20}: Yes, it does, because when we talk of scientific knowledge we are not talking about indigenous knowledge.

The four (4) teachers' responses are similar, as they, all believe that experiments develop the scientific knowledge. The teachers' reasons being that science requires facts and as such facts must be proven true. The teachers further stated that in order for a teacher to instil skills to learners', experiments play a pivotal role.

Q 05: ***How different are theories from laws?***

T_{17}: Theories are statements that are yet to be proven, while laws are graduated theories.

T_{18}: Theory is a law that is still developing in a way, a law is something that has been amended, and it has been tested and proven to be true and is being used in certain scientific aspects

T_{19}: Laws are made after theories.

T_{20}: Before you get to theory, you must first start with a hypothesis. When scientists are not sure of something they will make a hypothesis is tested and be proved correct and from there it becomes a law.

The four (4) teachers' responses are that scientific theory will eventually become a scientific law and such views are myths. This is depicted from the teachers' response that scientific theory leads to scientific law and their answers are all similar.

Q 06: ***Are there any scientific theories, which you do not agree with? If yes, what are they and how do you then teach topics that involve these theories?***

T_{17}: I disagree with the theory of evolution when it says humankind emanates from apes. Maybe is because I view things from beliefs (Christian point of view). I just teach it as expected.

T_{18}: Yes, the theory of evolution, I teach the subject for the sake of the learners to pass.

T_{19}: There are no theories that I disagree with.

T_{20}: The theory of Lamarck and the theory of evolution, I am teaching them because is part of the learners' syllabus.

Based on the responses from the four (4) teachers' there are three (3) teachers who disagree with scientific theories and they all have similar reasons for their disagreements. The three (3) teachers disagreed with the theory of evolution and their reasons are based on their beliefs. Furthermore, one (1) of the three (3) teachers disagrees with Lamarck's theory that animals developed organs that they frequently used. (Use and disuse). The teachers further stated that they just teach this theory for the sake of the children, so that they can pass and that they teach because is part of the syllabus. There was, however, one (1) teacher amongst the four (4) teachers who agreed with all theories and the reason was that people have different opinions.

Q 07: ***Are there scientific laws, which you do not agree with? if yes what are they and how then teach topics that involve them?***

T_{17}: The Newton's law of universal gravitation.

T_{18}: Lamarck's law of use and disuse. When I happen to teach that topic I just become neutral and teach it by the book.

T_{19}: I agree with laws because these laws are already being proved from theories.

T_{20}: The Newton's law of universal gravitation. I teach the subject for the sake of the learners to pass.

The four (4) teachers' responses reflected a trend of three (3) teachers who disagree with the Law of Universal Gravitation and Lamarck theory that was mistaken to be a law. One (1) of the two (2) teachers who disagreed with the Law of Universal Gravitation stated that if something heavy falls causes more harm than something lighter therefore the acceleration cannot be the same if the impact differs. The three (3) teachers claim that they teach the laws for the sake of the learners and that they are neutral when they teach. There was however, one (1) teacher T_{19} who agreed with every law.

Q 08: ***Do you think the knowledge that is produced by scientists ever change?***

T_{17}: Yes

T_{18}: Yes

T_{19}: Yes

T_{20}: Yes

The four (4) teachers from the question have been able to reflect informed views as they all agreed that knowledge produced by scientists change.

Q 09: ***If yes why do you think it changes? If no, why do you think it never changes?***

T_{17}: Science is tentative in nature.

T_{18}: Knowledge change in way that help them to develop.

T_{19}: Most of the times some scientists come up with some ideas as a results those ideas make you question some ideas that were there before those ones as a result knowledge would change.

T20: They change because the conditions that we find. The things in the world are not constant therefore as things change the information also changes.

The reasons given by the four (4) teachers on whether the knowledge produced by scientists varied but all of them made scientific sense. One (1) of the teachers stated that science is tentative in nature while others suggested that when scientific knowledge develops, sometimes what is known may change.

4.5 Conclusion

This chapter presented the findings from the study with some interpretation of the data collected in this study. The data presented was collected through three stages where the first data presented was from the open-ended questionnaire, the second data was from the lesson observation and final data presented was from the semi-structured interviews.

The next chapter provides discussions of the findings, conclusions, recommendations, limitations of the study and suggestions for future research.

CHAPTER FIVE: DISCUSSIONS OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented the results and the interpretations of the data collected in this study. It presented data from three stages, which were from the open-ended questionnaire, lesson observations and semi-structured interviews.

5.2 Discussions of findings

The discussions of the findings are treated in an integrated manner using the five (5) themes identified in the conceptual framework elaborated in chapter two (2) of this study. The five themes are as follow, science as a body of knowledge (theme 1), science as a way of thinking (theme 2), the investigative nature of science (theme 3), the creative nature of science (theme 4) and the interaction of science, technology and society (theme 5). In the discussions on the findings, data is drawn from different questions in the three (3) research instruments. In the discussions, the questions from which the data are drawn are tabulated prior to a discussion of each theme.

5.2.1 Theme 1 - Science as a body of knowledge

The discussions of findings related to this theme are drawn from data obtained from the questions listed in Table 15 from the three (3) instruments used in the study.

Table 15: Theme 1 – List of questions from which data is drawn

Research Instrument	Question Number
Open-ended Questionnaire	1. What is science? 6. What do you think scientific model is? 9(d). What does the word ' hypothesis' mean?
Lesson Observation	4. Overall comments and observations from the lesson
Semi-structured interview	1. In your own understanding, what is science and how does it differ from other subjects taught at your school? 2. In your view what is an experiment?

Discussions on findings related to theme 1

The responses by the teachers in the first question of the open-ended questionnaire (**Q 01**) revealed trends of informed views by fifteen teachers "*Science is the application of scientific enquiry through theories, models and laws to explain and predict events in the physical environment*". The response by one of the teachers resonates well with the fact that science is the application of evidence to build testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process (National Academy of Science, 2008). The teachers' response further revealed the awareness of the nature of science's tenets they exude. The tenets such as, scientific inquiry, theories, models and laws as part and parcel of science. There was, however, a group of five (5) teachers whose responses reflected shallow views of what science is. Their responses were short and unclear and this was seen on teacher T_8 who is one (1) of the five (5) teachers, responded by saying science is, "*science is the study of the universe"*. However, but there remains a need to understand that science is not an encyclopaedic knowledge about the universe, as an alternative it represents a practice for proposing and cultivating hypothetical explanations about the world that are subject to further testing and refinement (Richards & Walter, 1998). The response by one of the five teachers reveals naive views as the teacher further failed to go into details. This is because there may not be definitive scientific methods that define science, but there are aspects that must be discussed. Aspects such as all scientific ideas must obey the rules to observational or experimental information to be measured applicable (Bell, 2009). Therefore, such responses rendered the five teachers' views naive.

The fifth question (**Q 06**) had teachers with mixed responses. Eleven (11) teachers were able to reflect informed views of what scientific model is. The teachers' responses varied, but reflected a common understanding and most importantly their responses resonated well with Hawaii.edu (2017) which defines a scientific model as an abstract illustration whose function is to explain and predict experimental phenomena. There were, however, six (6) teachers whose responses reflected naive views. The teacher T_{15} is one (1) of the six (6) teachers and the alarming response provided by the teacher was that “*scientific model is laid down according to the rules*" with such response one (1) can only say the views are naive. The six (6) teachers were not the only teachers whose responses or lack thereof were concerning. There were also three (3) teachers whose views could not be determined as they failed to answer the question.

In the final question (**Q 09d**), fourteen (14) of the twenty (20) teachers were able to identify hypothesis as an "A *proposed idea or explanation that need to be tested through study and explanation*" which showed that they held informed views. There was however, a group of six teachers whose responses could be aligned with a myth as their responses reflected a hypothesis as more or less an educated guess, which is viewed as a myth. This is because McComas (1998) argued that if hypothesis "is always an educated guess" as asserted by people, the question remains, an educated guess of what? He stated that a hypothesis could best be defined as an immature theory (McComas, 1998). The responses of these teachers reflect views that emphasise and resonate with the findings by Dekkers & Mnisi (2003) when they conducted a study in Limpopo Province and they found that teachers believed in common myths about the nature of science. Although the majority of the responses on this question reflect informed views, but the six teachers' naive views create a concern that cannot be easily eluded.

Looking at the teaching and learning activities reflected by the teachers, starting with teacher T_{17} took the learners through the writing of chemical formulae on lesson one and expected the learners to determine conjugate bases acids. The teacher further encouraged the learners to write down chemical equations and determine the products of the reaction and this took place on the second lesson. On the third lesson, the teacher required the learners to balance the equations. The teacher's teaching activities were systematic as the teacher made sure that each lesson is successful by addressing prerequisite of each lesson properly. The three (3) teachers had a common strategy, and that was to hand-out some notes to the learners. This strategy led to learners either to not participating in the class or make noise. Their lessons varied but there was no effective lesson that was as effective as the lesson of teacher T_{17}. The teachers' success of the lessons varied, and this was largely based on the teaching and learning activities offered by the teachers.

Looking at the teachers' responses on what is science and how it differs from other subjects. This was the first question of the SSI all the teachers were able to describe or define what science is, but only two (2) teachers out of the four (4) were able to further outline on what distinguish science from the other subjects. The teachers were able to outline the practical part of science; the teachers further highlighted the focus that science places on experiments. This is supported by the notion that scientific explanations can be conditional from supportable data only, and observations and experiments must be reproducible and demonstrable by other people (McLelland, 2006). In other words, what makes science different is that science is based on information that can be calculated or seen and demonstrated by other scientists (McLelland, 2006). Although McComas (1998) argues that experiments are not the principal and sole route to scientific knowledge, but the acknowledgement that they serve as a useful tool in science as such they remain an integral part of science. Therefore, the four (4) teachers reflected informed views on outlining what science is, but only two (2) were able to further reflect informed views on how science differ from other subjects. While the last two (2) teachers failed to outline what makes science different from other subjects. Therefore, it is difficult to determine the views of the two teachers, as they were not able to distinguish science from other subjects

Looking at the four (4) teachers' responses to what an experiment is on the second question of the SSI the four (4) teachers were able to reflect informed views with knowledge of scientific concepts. This is because they were able to give correct explanation of what an experiment is. The four (4) teachers' responses differed but reflected common views that science experiments seek to determine the authenticity of a scientific phenomenon through observations, touching and smelling (McComas, 1998). This is confirmed in the Oxford English Dictionary (1961) which states that an experiment is a process undertaken to make a discovery, test a hypothesis or to reveal a known fact. Therefore, from the gathered responses reveal informed views by the four (4) teachers

Tabulated summary of findings of theme one (1): Science as body of knowledge

Table 16: Theme 1 – Summary of the number informed, uninformed and inadequate responses

Aspects of the above theme	**Number of informed views**	**Number of uninformed views**	**Number of inadequate response**
Scientific Models	11	6	3
Concepts	15	5	0
Principle (hypothesis)	14	6	0

Summary

This theme, Science as a body of knowledge, reflects on aspects of science such as scientific concepts, principles, laws, theories, models and facts. The majority of the teachers reflected informed views of scientific concepts such as the term science. Although some of the teachers reflected uninformed views, but the number of teachers with informed views were many. Majority of the teachers further reflected informed views on concepts such as models and hypothesis. Some of the teachers whose views were naive on what a hypothesis was. Their reflected responses are regarded myths.

The four (4) teachers reflected informed views or knowledge of scientific concepts such as what an experiment is. However, their responses during classroom observations reflected varied views. The evidence from classroom observation and interviews from three (3) out of four (4) teachers were contradictory, only one (1) teacher was able to reflect the knowledge reflected in the interviews.

5.2.2 Theme 2 - Science as a way of thinking

The discussions of findings related to this theme are drawn from data obtained from the questions listed in Table 16 from the three (3) instruments used in the study.

Table 17: Theme 2 – List of questions from which data is drawn

Research Instrument	**Question Number**
Open-ended Questionnaire	9(a) Please give an example of scientific law and of a scientific theory. 9(b) What differences are there between scientific law and

	scientific theory? 9(c) What similarities are there between a scientific law and scientific?
Lesson Observation	3. Brief description of how the teacher engaged learners in activities related to the nature of science.
Semi-structured interview	5. How different are theories from laws? 8. Do you think the knowledge that is produced by scientists ever change? If yes why do you think it changes? If no why do you think it never changes?

Discussions on findings related to theme 2

Out of the twenty (20) teachers fourteen (14) teachers in the seventh question (**Q 09a**) were able to state examples of scientific laws and six (6) teachers who gave definitions of scientific laws instead of examples. Furthermore, the responses reflected four (4) teachers who provided scientific theories definitions instead of examples. These teachers revealed views that lack understanding in scientific questions as such one (1) can conclude they have informed views of scientific knowledge of concepts, principles, laws, theories, models and facts (Ramnarain & Padayachee, 2015). This is because they did not only provide an example of scientific law or theory, but they went into details on what they are. Therefore, with these responses by the teachers we can conclude that all the twenty teachers' views of types of scientific laws and scientific theories are informed.

In the eighth question (**Q 09b**), there were thirteen teachers' (responses revealed informed views. This is deduced from teacher T_6 who is amongst the teachers whose views are informed stated that "*Scientific theory is an in-depth description or explanation of the observed phenomenon and scientific law is just a statement about an observed phenomenon. They remain true until proven otherwise*". This is confirmed by (Holton & Brush, 2000; McComas, 2003) that a scientific theory is an incorporation of concepts that seek to explain a phenomenon. That is an in-depth description-using scheme of concepts, while scientific laws are validated by hypothetic-deductive testing and are based on many facts, experiments and observations. These teachers failed to highlight, but they were able to voice that laws remain true until they are proven otherwise (Bell, 2009). There were other five teachers who believe that scientific theories lead to scientific laws, however, Bell (2009) argued that theories and laws constitute two distinct types of knowledge and one cannot change into the other. McComas (1998) further emphasises that the allegory of theories turning to laws deals with a common belief that with the amplified evidence there is a developmental progression through which ideas go by on their way to final acceptance as mature laws and this is a myth. There were also two (2) teachers (T_1 and T_2) did not answer the question. It was therefore difficult to conclude on their views.

The eighteen (18) teachers' responses to question number nine (**Q 09c**) were gave distinct responses that showed that they were aware of the similarities between the laws and theories. Teacher T_4 who formed part of the informed teachers deduced this from a response. The teacher gave a respond that scientific laws and scientific theories are similar because "*They are both based on a tested hypothesis and support empirical evidence*". This becomes relevant as literature suggest that scientific knowledge is based on empirical evidence (National Research Council, 2013). There were also two (2) teachers (T_2 and T_5) who did not answer the question. Therefore, these teachers' views on understanding scientific knowledge of concepts, principles, laws, theories, models and facts could not be determined (Ramnarain & Padayachee, 2015).

Looking at the brief description of how the teacher engaged learners in activities related to the nature of science, teacher T_{17} was able to successfully engage his learners into activities related to the nature of science. The teacher gave the learners examples of bases and acids with the dish washing liquid used in the kitchen as well as fizzy drinks and learners gave their own examples. The teacher brought sunlight liquid in the classroom and encouraged learners to write the name of any chemical used as part of the ingredients of the dish washing liquid. The teacher further encouraged the learners to write the chemical symbols of the chemical ingredients. The teacher brought vinegar in the classroom and encouraged learners to write the name of any ingredient used as part of the ingredients of the vinegar. The teacher further encouraged the learners to write the chemical symbols of the chemical ingredients. Scientists interpret things according to what they know and what they can see (Akerson *et al*, 2000; Water & Le, 2008). This was helpful for the learners learning process because they could see what the teacher was talking about. The teacher T_{18} was not able to engage the learners to any activities related to the nature of science until the third lesson where she engaged the learners through drawn electric circuits on the board. She explained to the learners and this made it difficult for the learners to make sense of what she was talking about. Therefore, the teacher was not able to engage the learner to activities that related to the nature of science. While teacher T_{20} was able to engage the learners in activities related to the nature of science by providing the learners different types of worms and different types of skeletons. She further emphasised the type of nutrients the organisms had within them. The Mopani worms were given as the proper example. The teacher helped learners to realise how the way people live can negatively affect and influence the environment. The teacher further highlighted that when the environment is negatively impacted, it can in return be dangerous to its inhabitants. The teacher further made the learners aware of the indigenous medication and how it is as effective as the Western medication. This led to the learners asking questions about animals' medication. The only teacher who throughout the lessons failed to fully engage the learners in activities related to the nature of science was teacher T_{19} whose learners were somehow uninterested to what the teacher offered. Therefore, the third area of observation reflected the two teachers' limited knowledge of engaging learners to activities relating to the nature of science. The two teachers throughout their lessons used chalk and board without any teaching aid that could have been useful to both teachers and the learners. According to Vhurumuku (2010), the majority of teachers do not have proper understanding of what science is. Vhurumuku (2010) further highlights that scientifically thinking people can make reasoned and informed decisions on issues related to any environment, including the classroom. The teachers have however, failed to reflect or translate what they claim to know into a lesson that was informative and benefiting to the learners, as such the teachers failed to promote scientific thinking during their classroom practice.

Looking at the four (4) teachers' responses on how different are theories are from laws which was on the fifth question of the SSI and four teachers revealed a very concerning view which reflected how ill-informed they are about the difference or similarities between a scientific law and theory. This is because all the four (4) teachers think that all the laws were once theories and once they were proved they became laws, hence they said, "*Theories are statements that are yet to be proven, while laws are graduated theories. A theory after being tested many times and yields* *the same results it can therefore be endorsed to become a law* ". The teachers' responses revealed naive views and such views are regarded to be myth (Dekker & Mnisi, 2003; McComas, 1998). Scientific laws and scientific theories are very diverse kinds of knowledge, but the misconception poses them as the same knowledge unlike construct (McComas, 1998). This is revealed in some literature that many people hold t misconception that theories are established and they become laws while in reality theories and laws comprise two diverse types of knowledge and one cannot transform into the other (Bell, 2009; Vhurumuku, 2010). Therefore, responses by the four (4) teachers revealed naive views that scientific theory lead to scientific laws.

When looking at the four (4) teachers' responses on knowledge produced by scientists ever changing. All the four teachers on the eighth question reflected the views that are informed. This is because they responded by saying that the knowledge produced by scientists does change. This reflects informed views by the teachers as science being tentative. Hence, all scientific knowledge is durable but subjected to revolutionise and the change in scientific knowledge is inevitable, because new observations may challenge prevailing theories and scientific laws, (Bell, 2009; Jonhston & Southerland, 2012; Vhurumuku, 2010). Therefore, their views from the interviews are informed.

Tabulated summary of findings of theme two (2): Science as a way of thinking

Table 18: Theme 2 – Summary of the number of informed, uninformed and inadequate responses

Aspects of the above theme	**Number of informed views**	**Number of uninformed views**	**Number of inadequate response**
Scientific law	14	6	0
Scientific theory	14	6	0
tentative	4	0	0
Differences between law and theory	13	5	2
Similarities between law and theory	18	0	2

Summary

The first theme, which is science as way of thinking, reflects on the scientific thinking and reasoning. This theme revealed informed views of most of the teachers' thinking that involve scientific thinking. There were also few teachers who reflected uninformed views that did not involve scientific thinking. The majority of the teachers were further able to reflect informed views on the similarities on scientific laws and theories with few teachers failing to reflect responses of informed views.

Only two (2) teachers out of the four were able to engage learners into activities related to the nature of science. This means that only two (2) teachers out of the four (4) were able to present in the classroom what they claimed to know during the interviews and responding to the open-ended questionnaires. The teachers were also able to reflect informed views of science being tentative as they all believed that knowledge produced by scientists change. There was, however, a concerning responses by the four teachers on the differences between laws and theories, all of the four (4) teachers believed that scientific theory leads to scientific law and this is a myth (Dekker & Mnisi, 2003; McComas, 1998).

5.2.3 Theme 3 - The investigative nature of science

The discussions of findings related to this theme are drawn from data obtained from the questions listed in Table 17 from the three (3) instruments used in the study.

Table 19: Theme 3 – List of questions from which data is drawn

Research Instrument	**Question Number**
Open-ended Questionnaire	7. Do you think that scientists use their imagination and creativity when they do investigations/ experiments?
Lesson Observation	2. Brief description of how the teacher got learners involved in the scientific processes.
Semi-structured interview	4. Does the development of scientific knowledge require experiments? Explain.

Discussions on findings related to theme 3

The teachers' responses on the sixth question (**Q 07**) revealed ten (10) teachers reflected informed views as they agreed that scientists use creativity and their imagination when they do investigations or experiments. One of these teacher's response was that "*reporting results, observations and drawing conclusions are part of investigation that uses creativity and imagination*". This suggestion appeared acceptable in the science community as it resonates with the idea that science in its nature is a creative endeavour, its indisputable scientific ideas are creations of the mind and hypothesis formation and modelling require imaginative and creative thinking (Hadzigeorgiou, 2012). There were, however, other six (6) teachers whose views were questionable. Some of these teachers believed that scientists rely on conclusions from previous findings, while others believed that science have rules that scientists must follow and therefore there is no place for creativity and imagination. Research clearly shows teachers do not adequately understand the nature of science as they think that all scientific investigations adheres to an equal laid down set of steps known as the scientific method (McLelland, 2006). The findings of such research are in contradiction with the known truth that there is no single guaranteed method of science that can account for the success of science, but understand that induction, the collection and interpretation of person's facts providing the unprocessed materials for laws and theories (McComas, 1998). The teachers' views proved to be in contradiction with aforementioned literature and further contradicted that creativity and imagination are the foundation of originality, the desire in the nature of science and scientists use them throughout their investigations (Bell, 2009). Therefore, this rendered such views uninformed or naive T_2 and T_5 did not answer the question and it makes it difficult to assume their views.

When looking at brief description of how the teacher got learners involved in the scientific processes. It was revealed that out of the four (4) teachers, it was only teacher T_{17} who was able to consistently get the learners involved in the scientific processes. The teacher's lessons were well planned out from lesson one (1) to lesson three (3). In lesson, one (1) the teacher was able to help learners learn how to determine conjugate base and acids, the following lesson he taught and got them involve in how to determine the products of the reactions. The last lesson the teacher helped the learners learn how to balance the equations after they determined the products of the reaction. In this case, the teacher was consistence in his methods and the learners learned. In the lessons of the other three (3) teachers, you will either find learners quiet and giving no independent response to the questions or find them paying no attention. It was only in the last lesson where teacher T_{18} was able to help learners determine the definition of Ohm's law through a formula R =V/I. Teacher T_{19} had lesson that bore no fruit, because there was no scientific process that the teacher took the learners through. While teacher T_{20} was able to contextualise the lessons as often as possible. This could be seen when the teacher tried to have the learners understand the difference between an exoskeleton and an endoskeleton and teacher further explained the importance of looking after the animals as their extinction could affect the ecosystem and lastly the teacher took the learners through the process of photosynthesis. Therefore, the second area of observations reflected how difficult it is for science teachers to teach without performing experiments. It also reflected how not enough it is to teach without demonstrating. According to (Vhurumuku, 2010), science teachers develop their understanding of the nature of science through experiences and experiments. These experiments and experiences enable the teachers to develop ideas, perceptions, beliefs, values and assumptions about what science is. There were only two (2) teachers amongst the four (4) who was able to engage the learners towards the investigative nature of science. This is because the only two (2) were able to reflect active aspect of investigation and learning in their classrooms and helped learners in the scientific investigation. The teachers who were able to engage the learners in the scientific processes they teach Physics and Life sciences respectively.

In the fourth question of the SSI all four (4) teachers have reflected informed views that whenever there is a scientific investigation taking place it needs to be tested and this is done through experiments. This is because the capacity for scientific investigation skill, related to the nature and function of science, is a “must” for effective science (Aktamis, 2012). Therefore, they all reflected informed views. Although there is an argument that experiments are not the most important and the only fundamental parameters leading an achievement to scientific knowledge, but the acknowledgement that they serve as a constructive instrument in science as such they remain an integral part of science (McComas, (1998). Therefore, the responses by the four (4) teachers revealed informed views.

Tabulated summary of findings of theme three (3): The investigative nature of science

Table 20: Theme 3 – Summary of the number of informed, uninformed and inadequate responses

Aspects of the above theme	**Number of informed views**	**Number of uninformed views**	**Number of inadequate response**
Imagination	10	6	4
Creativity	10	6	4
Scientific processes	1	3	0

Summary

The investigative nature of science is a theme that reflects the active aspect of inquiry and learning. The majority of the teachers reflected informed views on science requiring creativity and imagination. The teachers were further able to outline the importance of experiments in the classroom for improvement of the learners' understanding. There was, however, out of the four (4) teachers, only one (1) teacher who was able to consistently engage the learners in scientific processes, whilst the other teachers tried to engage the learners into scientific processes. This means there was only one (1) teacher (T_{17}) who was able to consistently reflect what he claimed to do in the classroom.

5.2.4 Theme 4 - The creative nature of science

The discussions of findings related to this theme are drawn from data obtained from the questions listed in Table 18 from the three (3) instruments used in the study.

Table 21: Theme 4 – List of questions from which data is drawn

Research Instrument	**Question Number**
Open-ended Questionnaire	3. Do you think the knowledge produced by scientists may change in the future? 4. How do scientists know that dinosaurs really existed?
Lesson Observation	5. Some specific observations.
Semi-structured interview	3. How does the presence or absence of experiments in your lesson affect your lessons?

Discussions on findings related to theme 4

The responses by the teachers in the third question (**Q 03**) from the OEQ revealed that fourteen (14) teachers are aware that science is tentative. The teachers' reasoning was also straight to the core and reflected knowledge of the nature of science as tentative. One (1) of the teachers' respond highlighted that "*scientists are constantly trying to make new discoveries to develop new concepts and theories*". This response along with the other thirteen (13) resonate with the studies around the world revealing that teachers possess adequate understanding of science as being tentative in nature (Abd-El-Khalick *et al*., 1998; Bell, Lederman & Abd-El-Khalick, 2000). This statement is a testament to the more number of teachers revealing informed views on the questions. This further suggests that all scientific knowledge is subjected to revolutionise and the change in scientific knowledge is inevitable, because new observations may challenge prevailing theories and scientific laws (Bell, 2009; Jonhston & Southerland, 2012). There were, however, three teachers (T_{10}; T_{12} and T_{13}) whose views substantiated otherwise. The teachers do not agree with the belief that science is tentative in nature. One (1) of the teachers argued that if scientific knowledge is tested and proven it would not change hence, the Newton's Law of Universal Gravity. The teachers' views raise an alarming issue, because sure response insinuates that theories and laws will never change, hence, Newton's Law of Universal Gravitation. This contradicts the fact that all scientific knowledge is subject to change in light of recent substantiation and new ways of ideas and even scientific laws do change (Bell, 2009). Southerland (2012) also confirmed this by suggesting that the change in scientific knowledge is expected, since new observations may defy customary theories and scientific laws. There was also (T_5; T_6 and T_8) who did not attempt to answer the question as such their views about science being tentative in nature could not be determined.

The response of the fourth question (**Q 04**) by the teachers revealed that the fifteen (15) teachers hold informed views about the existence of dinosaurs. This is picked in one (1) of the responses that stated that the fossils are the best evidence. In order to realise how people find out about dinosaurs we must gain knowledge about the stony bones fossils people found in the earth (Asimov, 1982). There were, however, other three (3) teachers whose responses were irrelevant and uninformed "*Through written information which is acquired by continuous study and research*". The responses revealed that the four (4) teachers' views are uniformed. In addition, there was also T_2 whose views could not be determined due to failing to respond the question about the existence of dinosaurs.

In the fifth and final area of observation, there is a reflection of teachers giving the learners the freedom to think. There was, however, a problem was the three (3) of the teachers were textbook bound with no sign of creativity or innovation. The learners were able to ask questions and complete the activities they were given, but the teachers could not do anything apart from the work and activities in the textbooks. The research argues that science class is supposed to provide the opportunity for learners to understand the roles and discrete and contributions of scientific tenets which is the complete opposite of what the three teachers displayed (McComas, 2003). According to (Bell, 2009) creativity and imagination is the foundation of originality, the desire in the nature of science and scientists use them throughout their investigations and endeavours. There was a lack of creativity in three observed lessons for the three (3) teachers.

The teacher T_{17} was mostly consistent throughout his three (3) lessons, except that during the first lesson the teacher was solely dependent on the textbook; however, during the second and the third lesson the teachers became spontaneous. The specific observations that were not accounted for by the teacher, most of them were beyond the teacher's control. The teacher could not provide learners with hands - on experience due to lack of teaching aids and apparatus. The learners were not allowed to design their own investigation due to the nature of the way the lesson was presented. When we look at the lessons presented by the teacher T_{18} there is consistency throughout the three (3) lessons except on lesson one (1) where the teacher did not start the lesson by asking the learners a question. However, the teacher on the next two (2) lessons started the lessons by asking the learners questions. Looking at the lessons presented by teacher T_{19} the teacher was consistent with he presented his lessons. The only different that could be picked from his lessons were that he could not provide any ay lesson activity that was on the level of the learners, because the teacher hardly gave the learners any activity. This teacher presented one (1) of the worst lessons in the classroom and it was difficult to determine as to whether the learners had anything solid that they learned. Teacher T_{20} also was consistent in her second and last lesson she presented. In the first lesson, the teacher did not start the lesson with a question as such; this led to learners' lack of interest in the subject matter. Most of the specific observations of the teacher were common to the other four (4) teachers.

The four (4) teachers have reflected informed views that science is effectively taught and fully understood when experiments are involved. Although there is an argument that experiments are not the most important and the only fundamental parameters leading an achievement to scientific knowledge, but the acknowledgement that they serve as a constructive instrument in science as such they remain an integral part of science (McComas, (1998). All the four (4) teachers argued that the absence of experiments in their classrooms makes difficult for their learners to easily grasp what is taught. Therefore, the responses by the four (4) teachers revealed informed views. This is due to the notion that an experiment is a process undertaken to make a discovery, test a hypothesis or to reveal a known fact, while science studies nature through a systematic organised knowledge by experimenting (Chan *et al*, 1998). Therefore, experiments play an imperative role in a science classroom.

Tabulated summary of findings of theme four (4): The creative nature of science

Table 22: Theme 4 – Summary of the number of informed, uninformed and inadequate responses

Aspects of the above theme	**Number of informed views**	**Number of uninformed views**	**Number of inadequate response**
Tentative	14	3	3
Empirical evidence	15	4	1
Observation	1	3	0

Summary

The creative nature of science, this theme encourages the scientific innovative side of the teacher in the classroom. The majority of the teachers reflected informed views of science being tentative in it nature. The majority of the teachers further revealed informed views of the historic part of science where they were able to outline on how scientists knew about the existence of dinosaurs. The teachers were also able to outline the importance of experiments in the classroom. All of the teachers claimed that the absence of experiments in their class affect the effectiveness of the lessons and deter their learners from effectively learning. Looking at some specific observations on the lesson observations, the teachers were consistent; however, there was only one (1) teacher out of four (4) teachers whose consistency was effective in the classroom.

5.2.5 Theme 5 - The interaction of science, technology and society

The discussions of findings related to this theme are drawn from data obtained from the questions listed in Table 19 from the three (3) instruments used in the study.

Table 23: Theme 5 – List of questions from which data is drawn

Research Instrument	**Question Number**
Open-ended Questionnaire	2. How is science different from the other subjects taught at your school?
Lesson Observation	1. Brief description of the lesson and the teaching strategy used by the teacher.
Semi-structured interview	6. Are there any scientific theories, which you do not agree with? If yes, what are they and how do you then teach topics that involve these theories? 7. Are there scientific laws, which you do not agree with? if yes what are they and how then teach topics that involve them?

Discussions on findings related to theme 5

The same trend of informed views in the second question (**Q 02**) of the OEQ by eighteen teachers was reflected as they outlined what sets science apart from other subjects (18). The teachers were able to highlight science as a practical subject that calls for an in-depth thinking and relies more on testing theories and experiments. This is because scientific explanations can be conditional from supportable data only, and observations and experiments must be reproducible and demonstrable by other people (McLelland, 2006). In other words, what makes science different is that science is based on information that can be calculated or seen and demonstrated by other scientists (McLelland, 2006). The eighteen (18) teachers were able to provide several accolades that set science apart from other subjects. The first part that the teachers highlighted was that science requires logical thinking; they further stated that science is more hands-on than other subjects and it requires more in-depth thinking. On the second part, the teachers were able to highlight that science is more practical focused and equip people with investigative skills. Although there was so much outlined by the majority of the teachers, there were teachers T_5 and T_{17} whose responses reflected no knowledge of how science differ from other subjects. This was because the teacher's response was somehow naive as the teacher stated, “science *teaches us things about science and teaches us how to do scientific studies on our own and science is treated as a golden subject*". The teacher was not able to outline why science is treated as a "golden subject" and failed to even outline that science uses confirmation to bring together testable explanations and predictions of natural phenomena and is grown through research and experiments that involves observations and that distinguish science from other disciplines of inquiry (The National Academy of Science, 2008). Therefore, most of the teachers amongst the twenty (20) were able to reflect informed views of how science is different from other subjects.

When looking at the brief description of the lesson and the teaching strategy used by the four (4) teachers. It was revealed that the four (4) teachers had similar classroom settings, where there was no apparatus or any science laboratory in the schools. The four (4) teachers' similar settings were further through same circuit and they are all based in Ga-Dikgale with just different villages. They reflected common teaching strategy during lesson one (1) which was whole class discussion. Teacher T_{18} further supplemented his strategy by facilitating while the three (3) remaining teachers supplemented theirs by further employing question and answer. In lesson two (2) and lesson three (3), the four (4) teachers remained constant with their teaching strategies, which were mainly whole class discussions and questions and answers. In my observations, it appeared as if the teachers had no other choice but to employ the strategies they employed due to lack of teaching aids. The observation area number one (1) of all four (4) teachers reflects the inability by the teachers to incorporate technology in any of the lesson each presented. This is not sufficient for learners to understand the nature of science. This is because in science, learners should not only be taught about scientific concepts, but should also be engaged in the scientific process (Vhurumuku, 2010). This will help learners to come to appreciate what characterises scientific knowledge and how it is developed (Vhurumuku, 2010). The four (4) observed teachers failed to reflect in their lessons the interaction of science, technology and society as the application of science and how technology affects humankind (Ramnarain & Padayachee, 2015). This is further emphasised by Vhurumuku (2010) that scientifically cultured people have an understanding of fundamental scientific knowledge, the nature of science and the connection between science, society and technology. It is therefore important for teachers to know that explanations that cannot be based on experimental substantiations are not part of science (National Academy of Science, 1998). This means that the incorporation of technology as teaching aids is important particularly in the absence of apparatus. In their interviews, all the teachers outlined the importance of experiments in their classroom as they help enhance the lessons and help learners to understand certain scientific phenomena that normally it would be difficult to understand.

The responses of the sixth question of the SSI there are three (3) teachers ($T_{17;}$ T_{18} and T_{20}) out of the four (4) who disagree with the theory of evolution. The teachers' reasons are based on their beliefs. This is because they said, "*I disagree with the theory of evolution when it says mankind emanates from apes. Maybe is because I view things from beliefs (Christian point of view*)". The three (3) teachers claimed that their beliefs never affect their classroom practices as they fully focus on what is in their textbooks. Learning science without having the correct conceptions of the nature of science is an error in science education, which warrants attention, and this concern extends to the science educators, as they are the front-line advocates in parting the right conceptions of nature of science (Jain *et al*, 2013). There was one (1) more teacher who said he disagreed with no theory as he said, "*Is difficult to argue or disagree with these theories because we have different perspective".* According to (Coleman, 2006) research has found many South African teachers due to naive views and lack of understanding of nature of science and have reservations teaching certain aspects or topics in science. Therefore, the teachers do not disagree with the theory, he just belief that people have different perspectives; hence, the four (4) teachers' views are uninformed views.

The responses on the seventh questions on whether teachers had any scientific laws they disagreed with, revealed that three (3) out of four (4) teachers ($T_{17;}$ T_{18} and T_{20}) disagreed with the Newton's Law of Universal Gravitation and Lamarck's law of use and disuse. The teachers failed to highlight or reflect the knowledge of laws remaining true until they are proven otherwise (Bell, 2009). Thus, their views are rendered uniformed. The last teacher (T_{19}) chose to refrain from disagreeing with laws are already proven as they were initially theories. This is because he said, *"I agree with laws because these laws are already being proved from theories*". This proves that as much as the teacher agrees with the laws he still holds uniformed views.

Tabulated summary of findings of theme five (5): The interaction of science, technology and society

Table 24: Theme 5 – Summary of the number of informed, uninformed and inadequate responses

Aspects of the above theme	**Number of informed views**	**Number of uninformed views**	**Number of inadequate response**
Concepts	2	2	0

Summary

The interaction of science, technology and society, this theme is the application of science and how technology affects humankind. The majority of the teachers were able to distinguish science from other subjects, while others failed to outline the difference. The four (4) teachers displayed common teaching strategies, but only one (1) teacher out of the four (4) was able to successfully employ the teaching strategies. The other three (3) teachers were not as successful as the first teacher. The three (3) teachers disagreed with laws and theories while only one (1) teacher found nothing wrong with any law or theory. The three teachers' views of scientific laws were based on their beliefs and they, however, claimed that their beliefs did not affect their classroom practices.

5.3 Findings linked to the research questions in the study

Question 1: What are science teachers' views about the nature of science?

5.3.1 *Findings related to research question 1 in the study*

In general, the findings of research question one (1) of this study indicated that most of the science teachers held informed views about the nature of science relating to scientific concepts, principles, laws, theories, models and facts. The findings further suggested that most of the science teachers held informed views about the nature of science relating to scientific reasoning. Few teachers reflected uninformed views on how scientists use creativity and imagination for their investigations, experiments and hypothesis testing. The teachers argued that science has inflexible rules, which must be shadowed in order to conduct scientific studies where there is no room for imagination or creativity.

Few teachers reflected uninformed views particularly teachers who were interviewed. The teachers reflected misconceptions noticeably about what a scientific theory and law are and how they differ. The teachers' views were that scientific theory leads to scientific law. This was not the only misconceptions identified on both responses from the questionnaires and the responses of interviews from the four (4) teachers (case study). There were also minimal number of teachers who reflected uninformed views about science being tentative in nature and this was identified from the responses on the questionnaires. The four (4) teachers (case study) however, reflected informed views with regard to reasoning about science being tentative and scientists using creativity and imaginations.

Question 2: How do the science teachers' views about the nature of science influence their classroom practices?

5.3.2 *Findings linked to research question 2 in the study*

In general, the results of research question number two (2) of this study indicated that what the teacher claim to know, is not successfully communicated to the learners in the classroom. This is because three (3) out of four (4) observed science teachers were unable to successfully show how their views influenced their classroom practices. This is despite their responses on both questionnaires and interviews showing that they hold informed views about the nature of science with very few misconceptions about few concepts such as science being tentative and differences between laws and theories. This maybe endorsed from the fact that teaching is a skill and having knowledge of a particular concept does not automatically equate to the ability to competently communicate it. In other words teaching and knowing are two completely different phenomena and as such they cannot be synonymised. Hence the findings reflected above.

5.4 Recommendation

The results presented in this study were gathered from twenty (20) teachers in one (1) circuit. The results, as already mentioned, cannot be generalised for all teachers in the cluster. Future research is suggested that among other aspects there should be different participant teachers from different clusters. The suggestion being that this type of study could be conducted on various scores of teachers, new-entrant teachers versus more experienced teachers or full time teachers versus temporary teachers, GET teachers versus FET science teachers.

Secondly, prolonged data collection with more than one (1) science topic presented by each science teacher could yield different results from the results of this study. Therefore, data collection should not be limited to three observations and one (1) interview with each teacher.

5.5 Limitations of the study

This research contained its limitations. At first the study was based on a relatively small sample of twenty teachers instead of a bigger sample.

Secondly the research targeted only FET science teachers. This meant that science teachers in the GET were excluded as such different views could have been established which in turn could have yielded different findings.

Finally, the research sampled only one circuit consisting of only thirteen high school. Had there been more schools in the circuit or more circuits been involved in the research, the finding could have taken a different and more meaningful direction due to more data processed.

5.6 Conclusions

The cross examining of the qualitative data from the open-ended questionnaire revealed that the majority of the teachers who participated in the study have informed views about the nature of science. There were however few teachers who did not answer some of the questions in the OEQ as such it is difficult to conclude their views and they are unknown. The minority of these teachers reflected an alarming myth of scientific theory becoming a scientific law. The trend of informed views of the nature of science by the teachers also emanated from semi structured interviews, but the teachers reflected the same trend of confusing scientific theory with scientific law.

The classroom observations, reflected a different turn of events as teachers were not able to reflect their informed views where one could determine how their views influence their classroom practices. Therefore, the nature of science in science education is the corner stone for both learners and teachers' success in science literacy. As such, the science teachers' views about the nature of science are more likely to affect or influence their classroom practices if the teachers are able to incorporate their knowledge with their skill to teach. This means that if the teachers' views about the nature of science are informed views and the teachers are able to incorporate such informed views with their skills to teach. Then the teachers are more likely to promote effective teaching and learning. If the teachers' views about the nature of science are uninformed or naive, the teachers are likely to unknowingly deprive learners of effective learning in the science classroom.

The data gathered from the three research instruments namely, the open-ended questionnaire, the classroom observations and the semi-structured interview highlighted informed views by the teachers, but also reflected the importance of skilful teaching or teaching as a skill.

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ANNEXURE A: Views of the nature of science open-ended questionnaire (VNOS D+)

I, Karabo Justice Chuene, learner number 200720281 am a learner at the University of Limpopo. I invite you to be a participant in my research project. My research a case study on **'Exploring science teachers' views about the nature of science and how these views influence their classroom practices'.** The data collected is strictly confidential and no real names will be used in the study. You have an option to remain anonymous in the study. Further, your participation in this study is voluntary. Should you agree to participate, you are free to decline to answer some questions or withdraw at any time during the process should you wish to do so.

Surname and initials: ....(optional) Date :.....................

Instructions

- Please answer each of the following questions. You can use all the space provided and the backs of the pages to answer a question.
- Some questions have more than one part. Please answer all parts.
- This is not a test. You will not receive a mark. Nothing you write will in any way be used to assess your performance in the programme you are in.
- All information you provide will be treated as confidential. Your name will not be used in any way except to compare your answers now with other answers later on.
- I am interested in your ideas relating to the following questions. There are no right or wrong ideas.

Personal details

a. Date of birth: .... b. Sex: M / F

b. Name of school: ....

c. Highest qualification: ....

d. Teaching experience in years: ....

e. All subjects taught in the past 3 years: ....

f. All grades taught in the past 3 years: ....

g. Number of learners in your largest class ....

1. What is science?

2. How is science different from the other subjects taught at your school?

3. Scientists produce scientific knowledge. Some of this Knowledge is found in science books and science textbooks. Do you think this knowledge may change in the future? Explain your answer and give an example.

4.

   a. How do scientists know that dinosaurs really existed?

6. What do you think a scientific model is?

7. Scientists try to find answers to their questions by doing investigations/ experiments. Do you think that scientists use their imagination and creativity when they do these investigation/ experiments? YES/ NO
   a. If NO, explain why?
   b. If YES, in what part(s) of their investigations (planning, experimenting, making observations, analysis of data, interpretation, reporting results, drawing conclusions, etc.) do you think they use their imagination and creativity? Give examples if you can.

9. a. Please give an example of a scientific law and of a scientific theory.

Scientific Law:

Scientific Theory:

   b. What differences are there between scientific law and scientific theory?
   c. What similarities are there between scientific law and scientific theory?

d. What does the word 'hypothesis' mean?

Thank you for completing this questionnaire. Your responses are appreciated.

ANNEXURE B: Lesson observation schedule

Name / Code of School: ____

Name / Code of Teacher: ____

Subject being taught: ____

Date of observation: ____

Grade: ______________________________

Lesson duration: __________ Start/End Time for lesson: ______________

Lesson Topic

____

____

Lesson Aims

____

____

SKAVs

____

____

____

Teaching and Learning Activities

1. **Brief description of the lesson and the teaching strategy used by the teacher**

2. **Brief description of how the teacher got learners involved in the scientific processes**

3. Brief description of how the teacher engaged learners in activities related to the nature of science

4. Overall comments and observations from the lesson

5. Some specific observations:

No	Did the teacher:	Yes	No
1	start the lesson with a question		
2	spark the learner curiosity or interest in his lesson introduction		
3	conduct a lesson on a topic is at an appropriate level for the learners		
4	design learning activities that enhance learners' scientific skills as per the CAPS policy document		
5	design learning activities that relate to learners' everyday lives		
6	design learning activities that allowed learners to use their imagination or creativity		
7	provides learners with "hands-on" experience of science		
8	allow learners to complete the learning activities in different ways		
9	allow learners sufficient time to fully explore the concepts of the lesson		
10	include the scientific process in the lesson		
11	use materials that are easy to obtain/use in the lesson		
12	allow learners to design their own investigation		
13	give the learners a worksheet so that they follow it and conduct an experiment		

14	use a learning activity from the textbook		
15	inquire about what the learner knows (prior knowledge on the topic)		
16	inform learners that theories, laws, etc. are subject to change		
17	get learners to infer or draw conclusion from data obtained		
18	allow learners to ask question for clarity		
19	solely dependent on the textbook		

ANNEXURE C: Interview schedule

- Please answer each question to the best of your ability.
- Nothing you say will in any way be used to assess your performance in the programme you are in.
- All information you provide will be treated as confidential and your name will not be used in any way, except to compare answers with other answers later on.
- This interview will take only 30 to 45 minutes.
- There are no right or wrong answers, the main interest is in your ideas relating to the following questions.

1. In your own understanding, what is science and how does it differ from other subjects taught at your school?
2. In your view what is an experiment?
3. How do the presence or absence of experiments in your lesson affect your lessons?
4. Does the development of scientific knowledge require experiments?
   - If yes explain why you say yes.
   - If no explain why you say no.
5. How different are theories from laws?
6. Are there any scientific theories which you do not agree with? if yes what are they and how do you then teach topics that involve these theories?
7. Are there scientific laws which you do not agree with? if yes what are they and how then teach topics that involve them?
8. Do you think the knowledge that is produced by scientists ever change?
9. If yes why do you think it changes? if no why do you think it never changes

ANNEXURE D: Consent letter

Dear participant

My name is Karabo Justice Chuene learner number 200720281 and am currently studying towards a Masters in Science Education. As a part of my study, I am required to carry out research titled: **Exploring science teachers' views about the nature of science and how these views influence their classroom practices.** The purpose of this study is to explore science teachers' views about the nature of science and how these views influence their classroom practices.

These observations and interviews are designed to explore:

❖ How do the science teachers' views about the nature of science influence their classroom practices?

I would appreciate it if you would allow me to spend little of your time with you for both the classroom observations and interviews. Please bear in mind that this is an academic endeavour, anonymity will be compulsory and the data collected will be used only for research purposes, and all responses are confidential and will be treated as such.

As a participate selected and agreed to partake in the study you will then be observed in your class for three lessons and interviewed after the being observed.

ARE THERE ANY CONDITIONS THAT MAY EXCLUDE YOU FROM PARTICIPATING IN THE STUDY?

❖ You must be a qualified teacher and currently teaching Physical Science or Life Sciences in Dimamo circuit.

❖ You must be at least 18 years old to participate in this research.

WHAT ARE WILL YOU BE REQUIRED OF YOU IN THE STUDY?

Should you decide to partake in the study, you should expect the following:

❖ To sign the consent form

❖ To be observed for three lessons by the researcher.

❖ To be interviewed by the researcher after the lesson observations.

WHAT ARE THE POSSIBLE BENEFITS THAT MAY ARISE FROM THE STUDY?

The benefits of participating in the study are as follows:

- ❖ This research will help improve your classroom practices and transform your views on the nature of science.
- ❖ Subject advisers. This research will help you to identify subject topics that need urgent attention for effective classroom practices. for subject meetings and how the nature of science in viewed in policy documents.
- ❖ This research will help you to identify targeted areas for professional development to you and other teacher.

WILL YOU RECEIVE ANY FINANCIAL COMPENSATION OR PAYMENTS FOR PARTICIPATING IN THE STUDY?

Please be informed and note that you will not receive any form of payment for taking part in the study.

WHAT ARE YOUR RIGHTS AS A PARTICIPANT IN THE STUDY?

You have the right to withdraw from participating in this study at any given time as your participation is voluntary. Should you wish to withdraw you will not be penalised or have any future disadvantages. You do not have to provide a reason for your decision to withdraw from participating in the study. You may also be excused from participation if you do not comply with the researcher's requirements as this may temper with the authenticity of the outcomes of the study.

HOW WILL CONFIDENTIALITY AND ANONYMITY BE ENSURED IN THE STUDY?

Confidentiality of the data will be kept and your identity will only be known to the researcher. Your identity will not be revealed during or after the study even when the study is published.

ANNEXURE E: Consent Form

I ______________________________ agree to participate in the research study named (**Exploring science teachers' views about the nature of science and how these views influence their classroom practices).**

The temperament and rationale of the study has been explained to me in writing and I am therefore participating voluntarily.

I give permission for my observation and interview with (researcher's name) ___________________ to be video and tape recorded.

I understand that no financial compensation will be made for participating in the study.

I understand that I can withdraw from the above stated research study, without any penalties, at any time, either before it commences or while I am participating.

I understand and accept all my rights as a participant.

I understand that anonymity will be ensured in the write-up by disguising my identity.

Signed: __________________________ Date: ___________________

ANNEXURE F: Interview transcripts for (T_{17})

1. In your own understanding, what is science and how does it differ from other subjects taught at your school?

   Science is a subject that deals with natural phenomena, is a subject that studies and wants to find out more or bring explanations to natural day to day occurrences. The differences between science and other subjects is that science is very practical and concrete, you are able to see what you are talking about, e.g. what they tell you about electricity, we all encounter with electricity and interact with it on a day to day basis with types of connections, parallels and series. Acids and base we use them daily. Basically science is a subject that deals with what we already know. It comes in as a subject that clarifies loop holes.

2. In your view what is an experiment?

   An experiment is just a piece of task where learners together with the educator will go a laboratory either at school or any other centre and they will be having apparatus which they will use to perform an experiment in verification of a certain principle that might have been learnt prior to that experiment. Actually experiments are there to prove hypothesis and certain abstracts and knowledge that we have and we use these experiments to verify.

3. How do the presence or absence of experiments in your lesson affect your lessons?

   The absence, the absence of experiments in my science lessons always affect the understanding or the grasping of the scientific knowledge negatively on the side of the learners, because there are certain topics which need to be practicalised (or seen done) where in learners have to undertake the process and see these things happening and so that they have a thorough understanding. The presence of experiments, makes the subject to be interesting and make the learners to think out of the box and be able to reason. Experiments also encourage personal generation of knowledge. When learners have seen a particular type of experiment they

become to be in a position where they can be able to say something about the chapter before you even say something about it.

4. Does the development of scientific knowledge require experiments?
   - If yes explain why you say **yes.**
   - If no explain why you say no.

   Yes, the development of scientific knowledge does require experiments, because remember that science is the study of things we already know, but we don't know that it is science, so we need proof, because everybody holds a certain understanding of science e.g. when our parents cook tribe they through in a spoon in the pot and that is science, but for one to tell the parents that this is science, you must do a particular experiment before the parents where you will cook with a spoon in the pot and without the spoon in the pot where we will measure the rate of reaction. Therefore, every scientific develop will need to be proved through experiment.

5. How different are theories from laws?

   Theories are statements that are yet to be proven, while laws are graduated theories. A theory after being tested many times and yields the same results it can therefore be endorsed to graduate as law.

6. Are there any scientific theories which you do not agree with? if yes what are they and how do you then teach topics that involve these theories?

   I disagree with the theory of evolution, when it says mankind emanates from apes. Moving from generations until they evolved to become humans. Maybe is because I view things from beliefs (Christian point of view). When I happen to teach that topic I just become neutral and teach it by the book and I try not to interfere because if I do I might end up being biased.

7. Are there scientific laws which you do not agree with? if yes what are they and how then teach topics that involve them?

   I agree with almost all the laws that govern my subject, However,, the Newton's law of universal gravitation, which says if you throw a stone and

a feather at the same time provided air resistances are negligible. When you try and practicalise it in the physical not a vacuum, if two people fall down where the other is big and the other is small the impact thereof differs, because if we are pull by gravity and it seems as if it also considers the size, because the impact will differ.

8. Do you think the knowledge that is produced by scientists ever change?
   Yes, science is tentative in nature.

9. If yes, why do you think it changes? if no why do you think it never changes?
   You will find when you read certain topics, laws are developed and improved from one scientist to the other.

ANNEXURE G: Interview transcripts for (T_{18})

1. In your own understanding, what is science and how does it differ from other subjects taught at your school?

   Science is just a study of the world and its interactions and the things that form the world.

2. In your view what is an experiment?

   According to my understanding an experiment is some sort of a scientific test in a way whereby you practically want to see something theoretical by putting it to the test which will help determine the behaviour of those phenomena. If you want to test if something will explode, what you will check is does it explode at that given time, and what causes delay if there is any, is the temperature high or low.

3. How do the presence or absence of experiments in your lesson affect your lessons?

   I believe the presence of experiments in a lesson makes it easy for the learners to understand what the teacher is talking about e.g. If you talk about potassium permanganate, the learners must know the colour and the smell of potassium permanganate, the learners must know if it's a solid or a liquid or a gas. The learners will not surely know this unless experiment is made. Therefore, these experiments make it easier for learners to understand because learners learn better through observing, touch and interact with things, because when you only explain things learners might create wrongs things in their minds.

4. Does the development of scientific knowledge require experiments?

   - If yes explain why you say **yes.**
   - If no explain why you say no.

   Yes, the development of scientific knowledge requires experiments, because we need facts and quality results that will contribute to the

development of science. This is because we cannot just bring ideas and approve them without testing their authenticity.

5. How different are theories from laws?
   According to my understanding a theory is a law that is still developing in a way and a law is something that has been amended and it has been tested and proven to be true and is being used in certain scientific aspects.

6. Are there any scientific theories which you do not agree with? if yes what are they and how do you then teach topics that involve these theories?
   Yes, the theory of evolution, apart from my Christian religion, i just don't find it to be true. Thinking of how human beings started from being apes and guerrillas and change to human being, I just don't buy it. I believe in God creating animals and human beings unlike a person evolving from apes because of temperature. I teach the subject for the sake of the learners to pass, but I personally do not believe in that, but I teach it because it is something that is going to be in the exam to help benefit the learners.

7. Are there scientific laws, which you do not agree with? if yes what are they and how then teach topics that involve them?
   The law of use and disuse, the law of Lamarck, where animals lose their body parts that they do not use.

8. Do you think the knowledge that is produced by scientists ever change?
   Yes, the knowledge change in way that help them to develop.

9. If yes, why do you think it changes? if no why do you think it never changes?
   They change because the conditions that we find. The things in the world are not constant therefore as things change the information also change.

ANNEXURE H: Interview transcripts for (T_{19})

1. In your own understanding, what is science and how does it differ from other subjects taught at your school?

   In science we use the scientific laws that are said and we must prove them and it differs with other subjects, because other subjects are theory orientated. Science focuses more on experiments.

2. In your view what is an experiment?

   An experiment is something used to prove scientific things by means of observing, touching and smelling.

3. How do the presence or absence of experiments in your lesson affect your lessons?

   Normally, the presence of experiments helps people to understand better, because if they see things, things that are tangible. This helps learners not to forget easily. But if learners are only told theoretically they easily forget.

4. Does the development of scientific knowledge require experiments?
   - If yes explain why you say **yes.**
   - If no explain why you say no.

     Yes, that is why our laboratory should have some of these apparatus that we use in that way it will instil some of the skills in the learners.

5. How different are theories from laws?

   Laws are made after theories. This means someone may come up with a theory and after scientific research is done from the theory and from there a law is made. Theories must be proved before they become laws.

6. Are there any scientific theories which you do not agree with? if yes what are they and how do you then teach topics that involve these theories?

   Is difficult to argue or disagree with these theories because we have different perspective. Therefore, no there are no theories that I disagree with.

7. Are there scientific laws which you do not agree with? if yes what are they and how then teach topics that involve them?
   I agree with laws because these laws are already being proved from theories.

8. Do you think the knowledge that is produced by scientists ever change?
   Yes

9. If yes, why do you think it changes? if no why do you think it never changes?
   Most of the times some scientists come up with some ideas as a results those ideas make you question some ideas that were there before those ones as a result knowledge will change.

ANNEXURE I: Interview transcripts for (T_{20})

1. In your own understanding, what is science and how does it differ from other subjects taught at your school?

   Science is knowledge about the real life situation of living organisms. It differs from other subjects in a sense that learners are aware of their surroundings compared to other subjects.

2. In your view what is an experiment?

   Experiment is a way in which one is trying to get the reality of the said statement. In order to prove whether the statement said is right or wrong one will have to make an experiment where we will have to observe. In other words, experiments are used to prove particular scientific statements whether they are true or false. Validity of statements.

3. How do the presence or absence of experiments in your lesson affect your lessons?

   They absence of experiments in the class affect the lessons negatively, because when you tell learners about the glucose testing you have to go to the laboratory so that learners can touch the instruments used, but when you just explain things the learners don't know. Some of the learners will have their own ideas and most of the time those ideas are wrong.

4. Does the development of scientific knowledge require experiments?
   - If yes explain why you say yes.
   - If no explain why you say no.

   Yes, it does, because when we talk of scientific knowledge we are not talking about indigenous knowledge. Therefore, indigenous this are no longer available so we depend more on scientific knowledge where things must first be tested before they are approved.

5. How different are theories from laws?

Before you get to theory, you must first start with a hypothesis. When scientists are not sure of something they will make a hypothesis. A hypothesis is a statement that needs to be proved through experimentation and being scientifically tested and proved to be correct then that statement is said to be theory. Am not sure but what I can say is a theory will remain to be a theory until is challenged by another scientist to add on or subtract on the existing theory from there it again be tested and be proved to be correct and from there it becomes a law.

6. Are there any scientific theories, which you do not agree with? if yes what are they and how do you then teach topics that involve these theories?
   The theory of Lamarck and the theory of Darwin (Evolution). I am teaching them because is part of the learners' syllabus.

7. Are there scientific laws which you do not agree with? if yes what are they and how then teach topics that involve them?
   Lamarck's Law of use and disuse. I teach this topic because I want the learners to pass.

8. Do you think the knowledge that is produced by scientists ever change?
   Yes, they change.
9. If yes, why do you think it changes? if no why do you think it never changes?
   When someone research and discover that someone made a mistake, the knowledge will have to change. There is always a room for mistakes in science there with such there is also always a room for improvement of knowledge.

ANNEXURE J: Letter to Limpopo Department of Education

UNIVERSITY OF LIMPOPO

DEPARTMENT OF MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION
TURFLOOP CAMPUS
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 2682697, Fax: (015) 2683208, Email:suresh.singh@ul.ac.za

TO:	THE HEAD OF DEPARTMENT LIMPOPO DEPARTMENT OF EDUCATION
DATE:	**01 March 2016**
SUBJECT:	**PERMISSION TO CONDUCT RESEARCH: Mr KJ CHUENE**

This serves to confirm that **KJ CHUENE** (Student No. **200720281**) is a bona-fide student of the University of Limpopo and is registered for a Masters in Science Education. I am his supervisor for his thesis. His research topic is: **'Exploring science teachers' views about the nature of science and how these views influence their classroom practices.'** The student would like permission to conduct research in the Dimamo Circuit of the Capricorn District. He wants to collect data in the second term of 2016. Kindly grant the student permission to conduct the research.

Kindly forward your permission to me on the email address listed above and to the student on chuenekj@gmail.com. Your swift response in this matter is greatly appreciated.

Yours in Education,

SK SINGH (Dr)
SUPERVISOR

KJ CHUENE (Mr)
STUDENT

Ref: Memo 29/2016 Permission to conduct research

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ANNEXURE K: Permission to conduct research from Limpopo Department of Education

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

Ref: 2/5/6/1 *Enq: MC Makola PhD* *Tel No: 015 290 9448* *E-mail:MakolaMC@edu.limpopo.gov.za*

Chuene KJ
Private Bag x1106
Sovenga
0727

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"EXPLORING SCIENCE TEACHERS VIEWA ABOUT THE NATURE OF SCIENCE AND HOW THESE VIEWS INFLUENCE THEIR CLASSROOM PRACTICES."**
3. The following conditions should be considered:

3.1 The research should not have any financial implications for Limpopo Department of Education.

3.2 Arrangements should be made with the Circuit Office and the schools concerned.

3.3 The conduct of research should not anyhow disrupt the academic programs at the schools.

3.4 The research should not be conducted during the time of Examinations especially the fourth term.

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

Request for permission to Conduct Research: Chuene KJ

CONFIDENTIAL

5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

-- 04/03/2016

MUTHEIWANA NB

HEAD OF DEPARTMENT (ACTING)

DATE

ANNEXURE L: Permission to conduct research from Dimamo Circuit

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

POLOKWANE DISTRICT

DIMAMO CIRCUIT

Enq.: Kgopa M.S

CONTACT: 0828178889

22.03.2016

Permission to conduct research: Chuene KJ Dimamo circuit

1. The above matter refers.
2. Kindly allow the educator to conduct research in Dimamo Circuit.
3. Provide the necessary support for the benefit of the Department of Education.
4. Hoping for a positive response as always.

....

Circuit Manager

ANNEXURE M: Faculty approval of proposal

University of Limpopo
Faculty of Humanities
Executive Dean
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 4895, Fax: (015) 268 3425, Email:richard.madadzhe@ul.ac.za

DATE: 15 September 2016

NAME OF STUDENT: **CHUENE, KJ**
STUDENT NUMBER: **[200720281]**
DEPARTMENT: **MEd – Science Education**
SCHOOL: **Education**

Dear Student

FACULTY APPROVAL OF PROPOSAL (PROPOSAL NO. FHDC2016/1897)

I have pleasure in informing you that your MEd proposal served at the Faculty Higher Degrees Meeting on 29 June 2016 and your title was approved as follows:

TITLE: EXPLORING SCIENCE TEACHERS' VIEWS ABOUT THE NATURE OF SCIENCE AND HOW THESE VIEWS INFLUENCE THEIR CLASSROOM PRACTICES

Note the following:

Ethical Clearance	**Tick One**
Requires no ethical clearance Proceed with the study	
Requires ethical clearance (Human) (TREC) (apply online) Proceed with the study only after receipt of ethical clearance certificate	√
Requires ethical clearance (Animal) (AREC) Proceed with the study only after receipt of ethical clearance certificate	

Yours faithfully

Prof RN Madadzhe
Executive Dean: Faculty of Humanities

Director: **Dr RS Maoto**
Supervisor: **Dr SK Singh**

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ANNEXURE M: Turfloop Research Ethics Committee Clearance Certificate

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**03 November 2016**
PROJECT NUMBER:	**TREC/223/2016: PG**

PROJECT:

Title:	Exploring science teachers' views about the nature of science and How these views influence their classroom practices
Researchers:	Mr KJ Chuene
Supervisor:	Dr SK Singh
Co-Supervisor:	N/A
School:	Education
Degree:	Masters in Science Education

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

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ANNEXURE N: Letter from the editor

Fax: 01526828683174
Tel. 0152862684
Cell: 0822198060
Rammalaj@ul.ac.za

Dr J R Rammala
440B Mankweng
Box 4019
Sovenga
0727

To whom it may concern

11 September 2017

Confirmation letter: KARABO JUSTICE CHUENE

Dear Sir/Madam

This memo serves to confirm that I edited a dissertation by the above-mentioned candidate entitled: **EXPLORING SCIENCE TEACHERS' VIEWS ABOUT THE NATURE OF SCIENCE AND HOW THESE VIEWS INFLUENCE THEIR CLASSROOM PRACTICES**

Editing was done on language, typesetting and technical appearance. There were not so many language errors. Technically the document was well written and not much was done is this area except rearranging headings and subheading in accordance with rules for the University of Limpopo Research Administration and Development.
There were a few repetitions which I corrected with the help of the student telephonically and through email communication.

I confirm that the document is now readable and clean with regard to language issues and recommend that it can be submitted for assessment.

Thanks

Signed: ....

Dr J R Rammala

ANNEXURE O: Turnitin Report

Exploring science teachers' views about the nature of science and how these views influence their classroom practices

ORIGINALITY REPORT

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