EXAMINING EDUCATORS' STRATEGIES FOR PROMOTING SCIENCE LEARNING AND SCIENCE LITERACY AMONG GRADE 9 LEARNERS IN A SOUTH AFRICAN RURAL EDUCATION DISTRICT

A thesis submitted in fulfilment of the requirements

for

the Degree of

Doctor of Philosophy (Education)

at the

UNIVERSITY OF FORT HARE

by

Nomxolisi Mtsi

Supervisor: Professor K. J. Mammen

2019

ABSTRACT

Science learning and Science Literacy (SL) play a crucial role in preparing learners to participate in the country's economy with the relevant knowledge, higher order thinking and analytical reasoning to solve day-to-day problems. The purpose of this research was to examine educators' strategies for promoting science learning and SL among grade 9 learners in a rural education district in South Africa's Eastern Cape Province. Learning of science and promotion of SL complement each other and therefore science educators' strategies are pertinent. The study used pragmatic paradigm and the mixed method approach and was informed by cognitive and social constructivism as theoretical frameworks. For data collection, the study used convenience sampling based on the proximity and comparative ease of the researcher to reach the rural schools to select 30 out of 67 schools spread over six out of the eight circuits in the selected education district. On the other hand, purposive sampling was used for the selection of learners by their educators based on academic performance, top, average and below average achievers. Since each school had only one grade 9 science educator, 30 grade 9 science educators from the selected 30 schools formed the sample for quantitative data. Out of these 30, 10 educators who volunteered first for interviews and gave permission for being observed in their classrooms were selected for qualitative data collection. Three learners in each of the 10 schools from which the educators for qualitative data collection were selected, constituted the learners' sample (30 learners). While data were collected through questionnaires, interviews and observations from educators, data from learners were collected through focus group (FG) interviews. The questionnaire was structured in order to gather educators' biographical data as well as information on educators' strategies to promote science learning and SL. The interview schedule was similar to the questionnaire but biographical data were excluded. Observations focused on educators' strategies for science learning, SL and assessments. The data from the questionnaire were descriptively analysed and the qualitative and transcribed observation data were thematically analysed. Final conclusions were drawn based on the triangulated data. Major findings showed that the strategies which the educators employed in the descending order of use were: Investigation at 97%; Discussion, Presentation and Project, each at 93%; Problem solving at 90%; Demonstration and Question-Answer, each at 87%; Case study and Brainstorming, each at 77%; Role-play at 63%; Lecture at 57%; Modelling at 47%, Inquiry at 27% and Simulation at 23%. Findings also revealed the strengths and weaknesses of the strategies used by educators. Some of the strengths were: promotion of interactive learning; stimulation of research skills; enhancement of critical thinking and development of confidence through participation. Some of the weaknesses were: learners' tendency to rely on others; lack of resources hindering learning and promotion of plagiarism. The study recommends that all stakeholders must work together to achieve good quality education. District and Provincial officers ought to track and monitor the science curriculum implementation. Subject specialists, educator subject committees and cluster leaders must also be active in strategic planning for enhancing SL in schools by putting forward their inputs and adopting consensus-based ones. A framework for driving science content with pedagogical content knowledge and practicals-driven strategy for enhancing science content knowledge is proposed.

Keywords: Educators; strategies; science learning; science literacy; knowledge

PLAGIARISM DECLARATION

I, Nomxolisi Mtsi, student number 200901232, hereby declare that I am fully aware of the University of Fort Hare's policy on plagiarism and I have taken every measure to comply with the policy.

Signature **Date: 02-01-2019**

University of Fort Hare
Together in Excellence

ETHICAL DECLARATION

I, Nomxolisi Mtsi, student number 200901232, hereby declare that I am fully aware of the University of Fort Hare's policy on research ethics and I have taken every precaution to comply with the regulations. I have obtained an ethical clearance certificate from the University of Fort Hare's Research Ethics Committee and my reference number is **MAM061SMTS01**

Signature **Date: 02-01-2019**

University of Fort Hare
Together in Excellence

DEDICATION

This doctoral thesis is dedicated to my one and only loving, beautiful daughter Athi whom I love and cherish with all my heart. She is my pillar of strength always there for me, encouraging and motivating me to follow my dreams and reach my destiny.

ACKNOWLEDGEMENTS

I would like to register my thankfulness to many people who assisted me in various ways to make this research possible, I would like to extend my sincere thanks and gratitude to all the wonderful people that God surrounded me with.

Firstly I thank the almighty for giving me strength to navigate the research journey and blessing my life beyond measure.

My deepest gratitude goes to my supervisor Professor K.J. Mammen who afforded me such an extraordinary opportunity. His guidance and support prepared me to work very hard. May God richly bless him.

I extend special thanks to the academics who were encouraging and supporting me during the research journey: Prof. C. Maphosa, Prof. P. Maseko, Dr. M. Rabaza, Dr. B Kumalo, Dr. M. Mashologu, Dr. S. Chiphambo and Dr.T. Mpiti.

I thank my immediate family for their support and constant prayers. My mother Magambu, my sister Zanele, my brother Siphelele, my niece Sihle and my cousin Nkulie.

A Special thanks to my colleagues who supported me in various ways: Mr T.Chikwanah assisted with statistical analysis, Miss G. Chisango discussing together mixed method techniques, Mr O. Madalambane and Mr Z. Sontshi for their advices.

Special mention also goes to: Mr L. Mbinda, Miss P. Binzani, Miss S. Bota, Miss M. Mali, and Miss L. Nomyayi for their special support during the research journey.

I am also grateful to the Goven Mbeki Research Development Centre for the financial assistance they offered me through the supervisory linked bursary.

The study would not have been possible had it not been for the cooperation I received from the Education District office (District Officials, Mr B. Yotsi and Mr Z. Kunene) and the schools that participated during data collection.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

CAPS:	Curriculum and Assessment Policy Statement
CK:	Content Knowledge
CK:	Curriculum Content
DBE:	Department of Basic Education
DST:	Department of Science and Technology
DOE:	Department of Education
ECDOE:	Eastern Cape Department of Education
ESD:	Education for Sustainable development
FG:	Focus Group
FFL:	Foundations For Learning
IBSE:	Inquiry Based Science Education
ICT:	Information and Communication Technology (technologies)
MKO:	More Knowledgeable Other
MMR:	Mixed Method Research
MSSI:	Mpumalanga Secondary Science Initiative
NECT:	National Education Collaboration Trust
NGOs:	Non Governmental Bodies
NS:	Natural Science
NCS:	National Curriculum Statement
PK:	Pedagogical Knowledge
PCK	Pedagogical Content Knowledge
PCKg	Pedagogical Content Knowing
PEA	Palestinian Evaluation Model
PoE	Predict-Observe-Explain strategy
RNCS:	Revised National Curriculum Statement
SAASTA:	South African Agency for Science and Technology Advancement
SES	Subject Education Specialist
SL:	Science Literacy
SPSS:	Statistical Package For Social Sciences

STS:	Science Technology and Society
TIMSS:	Trends in International Mathematics and Science Study
TK:	Technological Knowledge
TPACK:	Technological Pedagogical and Content Knowledge
TRAC SA:	Technology Research Activity Centre South Africa
TSPCK:	Topic Specific Pedagogical Content Knowledge
ZPD:	Zone of Proximal Development

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction to the study

Researchers such as Laugksch (2000), Salamon (2007) and Foster and Shiel-Rolle (2011) explain that there is a connection between science learning and promoting science literacy (SL) and the economic prosperity of a nation. Literature reveals that a country with citizens who are scientifically literate has high competitiveness implying that science literate individuals can enhance the economy of the country (Laugksch (2000); Salamon (2007); Foster & Shiel-Rolle, 2011).

According to Fraser-Abder (2011) existing evidence indicates that only a small percentage of learners who go through the school system develops science learning and SL. Fraser-Abder (2011) further notes that schools keep on producing graduates who lack a basic understanding of science and technology, harbour negative attitude towards science and possess inadequate critical thinking skills.

Millar (2007) and Tyler (2007) and the National Research Council (NRC, 2007 & 2012) highlight the notion that scientific content knowledge in a globalized society constitutes ‘core ideas’. These publications concur in considering core ideas as the overarching concepts, principles, and relationships between scientific ideas in the explanation and description of a host of phenomena that individuals experience in their lives. Core ideas allow learners to build integrated conceptual understanding that can be added and developed throughout their lives (NRC, 2007 & 2012). NRC (2012) further stresses that individuals who have an integrated understanding of core ideas are able to assimilate new ideas, apply them in order to solve problems and facilitate decision-making when needed. Examples of core ideas for science learning and promoting SL include, among others, energy, the particle nature of matter, biodiversity, patterns of change, systems and interactions, and sustainability (NRC, 2012). According to Norris and Phillips (2003); Yore and Treagust (2006), for one to be judged as science literate, he or she has to be proficient in the discourse of science which includes reading, writing and talking science. Proficiency in this context is considered as the ability to make informed judgements on societal issues based on SL (Hand, Prain & Yore, 2001; Norris & Phillips, 2003).

Fensham (2008) and Millar (2007) observe that SL which is currently high on the political agenda is based on the need to promote development and participation in science-related careers. Breiting and Schnack (2009) also note that Education for Sustainable Development (ESD) aims at promoting science literate societies which are able to make informed decisions concerning the natural environment and the promotion of sustainable livelihoods. According to Rosenburg (2007: 2), "ESD is a life-wide and life-long learning venture which challenges individuals, institutions and societies to view tomorrow as a day that belongs to all of us, or it will not belong to anyone". The present researcher is of the view that science is a subject that needs special treatment and everyone must participate in it to make a difference. For instance, more jobs require high level skills, people who are able to learn, to reason, to think creatively, to make decisions, and to solve problems related to global issues (Liu, 2009).

Learning science is something that learners do, not something that is done for them. This means that learners are to be encouraged to be actively involved both physically and mentally which Salama and Chennaoui (2016) denote collectively as SL enquiry. Educators depend on science strategies in order to enhance the promotion of science learning and SL. A strategy is a design for achieving a particular goal, that is, it is a plan which one willingly undertakes in order to improve the quality of the task ahead. Furthermore, it is the plan or approach they use to deliver each topic to be learned. Akdeniz (2016) explains that teaching strategies are also called instructional strategies. Akdeniz (2016) further explains that instructional strategies point to ways and approaches followed by educators to achieve the aims of instruction which are to apply the knowledge and achieve the objectives successfully. Instructional strategies require not only systematic guidance for learning but also a purposeful organization of experiences to help learners achieve the desired change in their performance (Simsek, 2011). Richardson (2001) avers that besides their studies of early progressivism Lev Vygotsky, Jean Piaget, Jerome Bruner and Albert Bandura also studied instructional strategies and created new theories. The new theories are cognitive psychology and constructivist approaches. Richardson (2001) points out that both these theories placed instructional strategies such as exploration and research-based teaching activities in the centre of the curriculum. The strategies link with the theories that inform the study in the theoretical framework. In this thesis, plans and strategies are used interchangeably.

1.2 Science learning and promotion of SL

Those who have an understanding of SL are usually referred to as scientifically literate (Turiman, Omar, Daud, & Osman, 2012). An individual can be said to be scientifically literate if that person understands science, the nature of science (the attitude and the process of science) and its relationship with society and the environment (Turiman, Omar, Daud, & Osman, 2012). Toth and Graham (2016) explain that individuals who are scientifically literate have the ability to evaluate a variety of news reports about everyday problems with a critical attitude towards the information, which involves using the values, norms and ideas based on evidence.

Literature suggests that there have been critical attempts to define and explain the meaning of SL and that there are multiple interpretations of what constitutes SL. For example, Murcia (2007) describes science learning and SL as the ability of an individual to blend the knowledge of important scientific literacy terms and concepts, the knowledge of the nature of science and the knowledge of the interaction of science and society. This researcher avers that the blending must occur within a contextual framework. The Program for International Student Assessment [PISA] (2012) cites the definition of SL suggested by the Organisation for Economic Cooperation and Development [OECD] (2009) as follows:

> … an individual's science literacy knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain science literacy phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology

> shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, as a reflective citizen (OECD, 2009: 14).

Yore & Treagust (2006) states that science learning and SL are more than the ability to read and write but for learners to be able to comprehend, apply, and understand science words in SL processes. As such, the learners must not rely only on the theoretical part of science, but also do hands-on activities following SL procedures. Examples of the procedures are: predict, observe, plan and do an investigation, record data, interpret and explain the outcomes. Science learning and SL are also seen as the skills to use SL knowledge in real situations and using evidence and data to evaluate the quality of information and SL arguments (Dragos & Mih, 2015). Science learning and promotion of SL are used almost invariably in the literature as synonyms.

Aspects of SL are expected to include values, morals and worldviews that can lead people to make appropriate choices and decisions to ensure a sustainable planet (Choi, Lee, Shin, Kim & Krajcik, 2011). However, individuals will also need to develop metacognitive skills in order to make sense of and use new complex scientific information. One can see that these definitions have something in common in that they promote science knowledge and SL concepts in order to solve day-to-day challenges. These aspects of SL ought to extend to contemporary views including the use of Information, Communication and Technology (ICT) and as such provide a new vision of scientific literacy.

Literature shows that SL is a challenge in developing countries or countries in transition due to insufficient qualified educators to teach science (Earnest & Treagust, 2007). Webb (2009) reported on a South African study on integrated learning strategies approach for science learning and promoting SL. As alluded to by Mtsi, Maphosa and Moyo (2016), educators in South Africa encounter challenges in terms of science resources, content knowledge and infrastructure. These challenges negatively impact upon the promotion of science learning and SL. In order to ascertain the context in the rural areas, this study was conducted at one rural education district in South Africa's Eastern Cape Province.

To summarise, for the purpose of this study, if learners are enabled to conduct science inquiry, predict-observe and explain as well as be able to apply ICT in gathering and disseminating science and its applications, they can be labelled as science literate. These aspects will be focused in this research.

1.3 International, African continental and South African efforts on science learning and SL

Studies on SL were carried out in several countries such as America (Hohenshel, 2004 and Nesmith, 2017), Canada (Mohammed, 2013), South Korea (Choi et al. 2011), Malaysia (O'Connell, 2014), Thailand (Dahsah & Faikama, 2008), Turkey (Kurt, Ekici, Aksu & Aktas, 2013); Indonesia (Salamon, 2007); Nigeria (Mandor, 2002; Ibe, 2004; Ajaja, 2009 and Ghumdia, 2016); Rwanda (Mugabo,2012); South Africa (Earnest & Treagust, 2007; Webb, 2009; Habteselassie, 2015 and Bantwini, 2017).

1.3.1 International studies

In the United states of America a study was conducted in Iowa State University on science learning and SL through the implementation of writing to learn strategies (Hohenshel, 2004). Referring to, Millar (1993) and Millar (1998), Hohenshel's (2004) report mentions different views on science learning and SL and cited three criteria for SL: (a) one who has enough base science vocabulary to read media reports, (b) an understanding of the science inquiry process, and (c) an understanding of the impact of science and technology on society. The author attempts to emphasize that to be literate means not just to read literature but also to communicate with understanding both verbally and in writing. Findings of this study reveal that: (a) multiple writing task provides cumulative benefits and learners using non-traditional writing to learn experiences are at an advantage compared to learners with traditional writing experiences; (b) learners using a non-traditional approach, with traditional writing template to scaffold their inquiry based laboratory writing perfomed better than learners writing in a conventional format on assessment; (c) the traditional writing routine common in science classrooms provides no guidance to assist learners in structuring their writing. Both groups however had planning exercises. Planning support was seen to be an essential component for writing to serve student learning. Hohenshel (2004) highlights that such planning strategy support for writing is provided through constructive scaffolding experiences. Furthermore, scaffolding is considered as very helpful since it includes writing tools and strategies that promote learning.

Therefore, science learning and promoting SL through implementation of writing can be enhanced with assistance from educators. As such, constructive scaffolding experience reported by Hohenshell (2004) is pertinent in science learning and promoting SL.

Twenty First Century Science (2008) states that in Britain, the programme aimed at piloting an optional course called *Science for Public Understanding*. It was targeting the 17-18 year olds, preparing them for a curriculum that will serve the purpose of promoting science learning and SL. Another course was developed for the younger, 14-16 year olds. Basically, the one for the younger age group concentrated more on the core curriculum that explored both the major explanatory themes of science and a set of ‘ideas-about-science’ that all learners had to learn. It also included a course of academic science which was meant for those who wished to pursue the study of science at a later stage. However, learners with a more vocational learning inclination were advised to take a course in applied science.

The Twenty First Century Science (2008) further states that Europeans would expect a science literate person to be able to appreciate and understand the impact of science and technology on everyday life. This would be accomplished when it enables one to take informed personal decisions about things that involve science, such as health, diet or use of energy resources and to take part confidently in discussions with others about issues involving science (Twenty First Century Science, 2008). In support of the aforesaid statement the present researcher is of the view that a science literate person uses higher order reasoning to come up with advices and solutions concerning issues that involve science. Learners will also be able to make use of SL knowledge to do a thorough research in solving such problems. Mostly in Europe they use a programme called European Union’s Framework Programme 7 (FP7) which accelerates the strategy through booklets, conferences, field visits, training sessions and “twinning“, or transferring knowledge between countries. There are some attempts by the Europeans to make science education fit for its purpose in terms of curriculum and pedagogy. The combination of curriculum and pedagogy implies that the curriculum must go with the relevant pedagogies that will promote science teaching and learning. In countries like Turkey, science is compulsory from grade 4 to grade 8 in order to develop learners in many sources of knowledge and is utilized in developing technological products such as imagination, creative thinking, culture and traditions as well as mathematical knowledge (Kurt, Ekici, Aksu & Aktas, 2013).

FP7 supported around 20 international projects aimed at improving science education, with many of them focusing on IBSE (O'Connell, 2014). The report further mentioned that FP7-funded Fibonacci Programme successfully disseminated Inquiry-Based Science and Mathematics Education in Europe through booklets, conferences, field visits, training sessions and "twinning", or transferring knowledge between countries. It is clear that in Europe the inquiry strategy is working for them while in Africa there are still some challenges. The success of the strategy is enhanced more by the FP7 programme which uses different interventions to promote the use of the strategy. In United States of America a study was conducted by Nesmith (2017) on educators' perceptions towards using literacy strategies in inquiry-based science lessons. It emanated from the study that the majority of the participants acknowledged the value of using the strategies though they do not use them often. The reason is the challenges such as lack of literacy methods, reluctance to incorporate literacy strategies due to the outcomes expected from the strategies and lengthy time e.g. the strategy takes more time than the science lesson time specified by the policy. They complain that the teaching time is affected. Furthermore, others experience difficulties to distinguish between the implementation of children's literature and implementation of literacy strategies.

In promoting science learning and SL, inquiry based teaching and learning has been considered as relevant. According to O'Connell (2014), in countries like Malaysia a pilot programme was implemented on Inquiry Based Science Education (IBSE) and it emerged that IBSE had positive outcomes for educators and learners. The above report also mentioned that in Mexico IBSE was tried and it reached 400 000 learners and around 10 000 educators. O'Connell (2014), revealed that IBSE has emerged as a prominent alternative to traditional science education, and it has been the subject of international research.

Choi, et al. (2011) report on the developments in South Korea, posit that emphasis is placed on citizens of the twenty-first century who need to develop an integrated understanding of the core ideas of science as well as important scientific reasoning and practices. The understanding that science is a human endeavour is also emphasised.

In Thailand, school science curriculum features science learning and promoting SL and many schools use a Science Technology and Society (STS) approach to teaching, emphasizing more on SL achievement rather than learning science for everyday life. The value of Thailand science education is still interpreted in economic terms. Dahsah and Faikama (2008) argue that Science and Mathematics Education is seen as a key economic enabler in a competitive world.

In Indonesia, learning strategy to improve science learning and SL was constructed by combining reading and writing and is done with a few strategies such as teaching problem-based learning and inquiry-based learning (Salamon, 2007), with emphasis on the process of investigation that combines the knowledge, understanding and mastery of the strategies to solve everyday problems (Oluwatelure, 2012).

India launched an ambitious programme in 2008, “INSPIRE” in consultation with the Indian National Science Academy and other Science and Engineering Academies. The programme was meant to attract and motivate a large number of young learners to opt for a career in science. In these INSPIRE camps, sessions were held for counselling parents on the attractiveness of careers in science and research,thereby encouraging the development of inquiry and the SL process, as well as generating excitement about the potential of careers in SL disciplines (ICSU, 2011).

1.3.2 African continental and South African efforts

In Africa, science curricula are often reviewed and revised to ensure that SL skills and knowledge offered are relevant to the economic needs of a particular country. Ajaja (2009) states that in Nigeria the sciences are taught in school subjects such as Biology, Chemistry and Physics. Some of the major objectives in teaching science are to ensure that learners acquire skills of SL method and have “clear explanations for societal issues through increasing interest in science learning and SL and societal goals” (Ajaja, 2009: 119). In the African context they use the strategy but lack experts in the field and take a negative attitude towards the approach.

O'Connell (2014) mentions that in Africa the Network of African Science Academic (NASAC) which includes 19 members from a range of nations has viewed ISBE as a preferable approach to teaching and learning sciences. They also mention that there is a range of initiatives relating to ISBE in Africa, particularly to raise awareness of ISBE, however there are still challenges in mastering the approach (O'Connell, 2014). O'Connell (2014) also notes that although the IBSE strategy motivates children and builds critical thinking, there are challenges in the use of the strategy such as lack of resources for training educators to use ISBE successfully.

Literature shows, among others, the role of three strategies in promoting SL: Science inquiry (Habteselassie, 2015), POE (Kibirige, Osodo & Tlala, 2014) and ICT (Bantwini, 2017). In addition Bantwini (2017) notes that to accommodate every learner, educators should explore various teaching approaches that can benefit different learners. The present researcher is of the opinion that if relevant strategies are not used by educators to promote SL, learners will suffer. It can also be the reason why there are few learners who pursue science at high school and tertiary levels. According to the 'Curriculum and Assessment Policy Statement' abbreviated as CAPS, effective learning occurs when the conditions for learning are maximised through the deliberate use of instructional design principles that consider learning differences and increase the possibilities of success for all learners (DBE, 2011). Educators and learners complain about experiencing challenges in science concepts which they do not understand (Mtsi, 2015). There is scarcity of reports on research done on the strategies educators use in promoting science learning and SL in rural schools through CAPS and the strengths and weaknesses of those strategies. Furthermore, reports on the support which educators receive in science learning and promoting SL and the assessment in science learning and SL are also scarce.

1.3.3 Educators' strategies for science learning and promotion of SL

1.3.3.1 Inquiry-based learning

A study was conducted in Nigeria on the effects of inquiry based teaching strategy on students' science process skills (Ghumdia, 2016). The study took place in Bono state in Nigeria to investigate the effects of inquiry strategy on secondary school biology students' achievements in science process skills acquisition. The study sample was one hundred and sixty senior secondary schools, and they used an instrument called biology student process skill acquisition test for data collection. The study findings reveal that, inquiry strategy contributed significantly to a better understanding of biological concepts by learners than their counterparts treated with conventional strategy. The findings were in line with those of previous researchers who indicated that active participation of learners gives more meaningful and effective learning (Mandor, 2002; Ibe, 2004). The study also revealed that there was a need for total involvement in the education system in Nigeria. The author further mentioned educational implications concerning the study, for instance the inquiry strategy could provide quick and easy understanding, assimilation of biological terminologies and acquisition of science process skills to solve biological problems. Additionally, the study also mentioned that biology educators must implement the curriculum in a way that will develop learners' solving ability and recommended that inquiry strategy should be adapted as a viable strategy for studying abstract concepts in biology.

Based on a study by Mugabo (2012) on science inquiry, there are a few educators who lack understanding of inquiry teaching. Mugabo (2012) further mentions that educators had a positive attitude towards the introduction of inquiry although they indicated a number of challenges such as traditional classroom activities dominating inquiry based activities.

In South Africa, the main aim of natural science curriculum is science learning and promoting SL (Department of Education, 2005). However, South African grade 8 learners performed poorly in science and maths according to the Third International Mathematics and Science (TIMSS, 2003).TIMSS also mentioned that learners in primary and middle schools are approximately three years behind where they could expect to be in terms of language, science and mathematics achievement. The findings of the study came under the following aspects:

- Classroom discussions: qualitative data from classroom observations revealed that in terms of the criteria for discussions used in the study, discussions were uncommon.
- Classroom observations, discussions of explanatory nature: These had not taken place in any of the control group lessons.

However, from the interview data all members of the experimental group of educators agreed that the rules of the game of classroom discussions helped them to facilitate discussions in their classrooms. In connection with science note books, data revealed an overall increase in aggregate scores for three educators who participated in the science note books approach workshop. The increase of scores was reflected in each individual educators' case from the baseline until the third and final lesson. Baseline observation data revealed that ideas generated through the process were not based on supportive data but on intuitively based claims (level one type argument). Secondly no acceptable data were provided to support the claims made by the learners during the expected activities. Therefore, learning was classified at the lowest level (Webb, 2009).

Language is an important factor that learners need to understand in order to fully participate in practical activities that will assist in promoting science learning and SL. Webb (2009) states that teaching and learning of science often take place in a second or foreign language for both the educator and the learner. Data revealed that, in the integrated strategies approach, educators chose to teach in their home language and code switch into English. Data also revealed that learners used isiXhosa during classroom discussions. The observed lesson indicated that educators had adequate understanding of the science learning and SL strategy, but they provided no planned activities to test learners' listening skills. Webb (2009) was also looking at integrated strategies i.e. writing strategy, discussion strategy and argumentation.

Habteselassie (2015) conducted a study in Gauteng Province in South Africa in order to investigate the nature and extent of inquiry practices in high school science classrooms. It was a mixed method study. The conclusions note that most of the educators had a good understanding of science inquiry and regarded it as a useful strategy. Nonetheless, only two classrooms out of 10 confirmed its use. Mtsi (2015) indicates that many educators criticise CAPS policy for not giving enough time for being prescriptive and focus on content, which they regard as obstacles to inquiry based practice. The present researcher is of the view that the inquiry strategy includes aspects that are very significant in science namely simulation, project work, demonstration, experiment and field work. If these are not used in the teaching and learning of science and promoting SL the students' SL knowledge will be inhibited.

A study conducted by Bantwini (2017) on science and technology in South Africa's Eastern Cape Province reveals that educators do not adequately promote inquiry abilities in learners as they learn through transmission (chalk and talk) of established knowledge. Bantwini (2017) further mentions that the majority of classes lack practical exercises, thereby hindering deeper learning of science content knowledge and critical thinking. This is because schools lack the resources and space for learners to move around and do science inquiry activities and that made the environment hardly conducive to attaining the teaching and learning objectives in terms of learner interaction and teaching approach. Additionally, the author highlights the challenges on strategies used in some of the schools as they do not attract and inspire young learners to continue studying science at higher levels. The criticism was that the teaching approaches used were intellectually non-stimulating, making science boring and confusing, as they treated the subject as isolated from learners' daily lives. It was also noted that educators lacked the ability to reflect on their own practice. Certainly, the report shows that there is a challenge regarding the strategies for science learning and promoting SL in our schools in the Eastern Cape Province.

1.3.3.2 Predict-Observe-Explain Strategy

Predict-Observe-Explain Strategy has also been found useful in science learning and promoting SL. In Thailand the strategy was used. The strategy provided learners to generate their own conceptual knowledge, reconciliation and negotiation between their prior knowledge and new experiences (Saowapak, Wanrawee, Pintip & Duangjai, 2010). The authors above stressed that the results of the study showed that learners in Thailand had a positive attitude towards the strategy. Babajide (2010) notes that Predict-Observe-Explain instructional strategy (POE) is effective in the development of practical skills in senior secondary schools . In Nigeria they see the strategy as successful . The constructivism approach is also promoted.

In South Africa the POE strategy by Kibirige, Osodo and Tlala (2014) indicated that learners taught using POE performed better than their counterparts in the control group. It shows that the strategy is working for South Africa, however, there are challenges in resources. The study conducted by Mtsi and Maphosa (2016) on challenges encountered in the teaching and learning of natural science in rural schools in South Africa reveals that the resources need to be available to enable proper teaching of science. They further note that teaching and learning of natural science becomes a challenge when basic requirements are not available.

In South Africa the studies conducted display that the strategy is still in progress but there are barriers faced by educators such as lack of resources to do practical activities, lack of practical activities that will promote science inquiry, lack of space and boring strategies that do not inspire learners but only confuse them. CAPS policy document also poses a challenge. In the African context the strategy is used positively but there is a lack of resources for training educators to use the strategy successfully. It means the developed and the developing countries are using the strategy, however, there are still some challenges that need intervention. It means here in South Africa there is a lot to be done to make the science inquiry work effectively. Regarding the use of POE strategy all the countries use the strategy successfully, but in South Africa a challenge in resources to enhance the strategy exists.

1.3.3.3 ICT in science learning and promoting SL

A study was conducted in Canada on the topic 'science learning and promoting SL' by using Information and Communication Technology (ICT) in science teaching (Mohammed, 2013). The study aimed at identifying the ways in which ICT can be employed in science teaching to develop science learning and promote SL. Literature highlights that growth of science learning and promoting SL lead to economic growth and social stability at political and social level (Bidokoth & Assareh, 2011). The most important tool in our present time to head towards a reasonable level of science learning and SL is ICT (Arntzen, Krug & Wen 2008 and Mirskaya 2007). Their study examined how ICT could reform SL awareness and they began a pioneering project of promoting science learning and SL. The study was conducted in a science college with experimental (using ICT) and control groups (not using ICT) involving physics students. A test was used to check the level of science learning and SL among the two groups. The data revealed that teaching using ICT was effective for acquisition of SL concepts and growth of SL knowledge among learners. The study recommended the use of constructivist learning strategies in order to enhance science learning and SL. Mohammed (2013) refers to a model that can assist educators to give advanced level of SL knowledge to their learners. The model is called Palestinian Evaluation Model (PEA model). It focuses mainly on using ICT in a way consistent with the tendencies and attittudes of the learners. PEA model promotes constructivist classroom and provides a social learning environment.

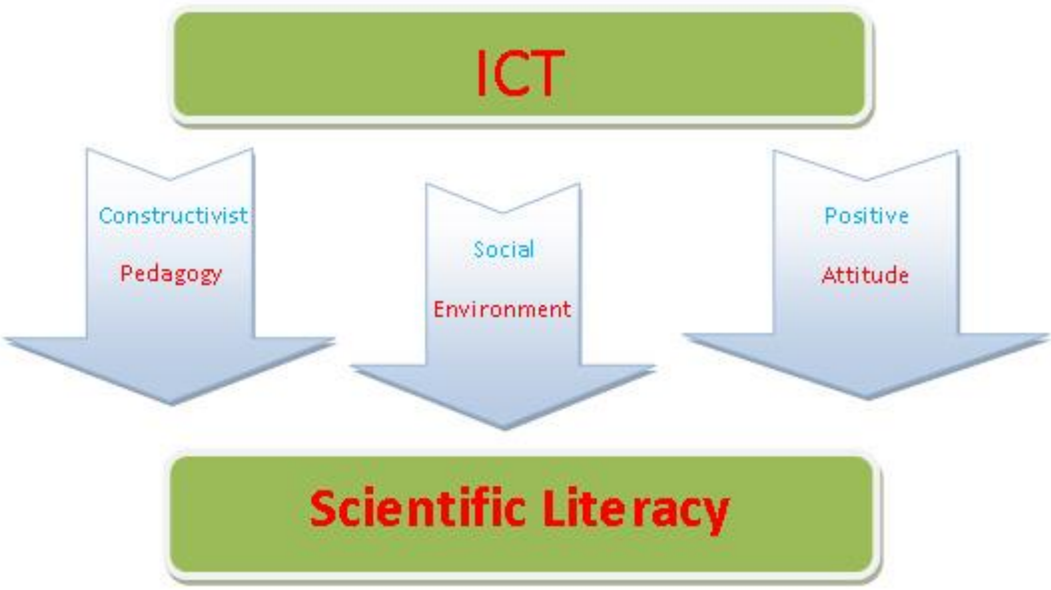


Figure 1-1: PEA Model

Mohammed (2013) confirmed that the PEA model depended on the use of ICT in the teaching of science based on the following three requirements:

- Using ICT in a way that is consistent with the tendencies and attittudes of the learners.
- Constructing educational content based on the constructivist theory of learning.
- Providing a social learning environment.

The present researcher interprets the above requirements combined together in the use of ICT as a way of successful science teaching. For instance, firstly, providing a good social learning environment where resources are accessible and easy to use together with the knowledge on how to use them is beneficial. Secondly, clear content being taught using constructive theory will engage learners more. Students' attitude will be influenced positively if the resources are available and if there is interactive learning. Mohammed (2013) also states that educators will benefit since the PEA model includes trainings to prepare school educators and faculty members in the universities to apply such educational strategy.

Information Communication and Technology (ICT) has become educationally useful and its use in promoting science learning and SL cannot be underestimated. In

California a project called weSPOT aimed to spread SL inquiry as the approach for science learning and teaching in combination with today's curricular and teaching practices like online learning (Okada, 2013). Furthermore, the author notes that the project weSPOT was developing a working environment with social, personal and open technologies to support users to develop their inquiry based learning skills. Subsequently, the author also mentions that the web based inquiry science is comprised of 15 000 science educators, researchers and curriculum designers, as well as 100 000 learners. Undoubtedly there is evidence that in California the use of ICT to enhance science inquiry is still active and successful. The evidence is the programme Vision 2020 which requires expertise in the field. The use of ICT internationally is working and yet in Malaysia the study conducted showed that only a few had knowledge and understanding of the strategy. Another study conducted in Malaysia by Suleiman, Bakar, Arshad, Ismail and Abdullah (2013) note that science education is preparing for a more relevant footing in the 21st century by emphasizing the promotion of science learning and SL through a more meaningful education programme called ICT. However, results showed that only 50% of the participants had knowledge and understanding of the programme. The author also mentioned that educators needed to be exposed to pre-service or in-service training. Furthermore, the author states that in its effort to achieve Vision 2020, Malaysia requires more competent scientists and technologists. Certainly it shows that ICT strategy is used in Malaysia, nevertheless there are still challenges.

In Africa, ICT is practiced but there are challenges. United Nations Educational Scientific and Cultural Organisation (2015) hosted a Southern Africa regional meeting concerning the integration of ICTs in teaching and learning. Although most of the countries in the Southern Africa region are very different when it comes to ICT readiness, they are facing similar challenges regarding their integration efforts like infrastructure and educator training i.e. lack of experts, attitude, mind-set, cultural aspect and fears.However ,it shows that the Southern Africa region uses ICT integration to enhance science inquiry despite challenges.

A study conducted in South Africa showed that science educators had access to ICT but experienced challenges in resources (Drape, 2010). Furthermore, it was reported that educators had no access to personal computer, laptop or desktop in the classroom (Drape, 2010). If educators do not have access to computers at work, how can the teaching and learning of science be successful? The use of ICT can assist educators to get current science strategies from other countries and conduct the experiments step by step. Ngubeni (2014) notes that ICT integration is active in South Africa although there are still barriers that exist in some provinces. Some of the barriers mentioned are inadequate infrastructure, computers and electricity. Despite various countries' attention to science education, in South Africa such attention has not been much, especially in the Natural Sciences and Technology lessons (Bantwini, 2017). Set, Hadman and Ashipala (2017) concur with Bantwini by mentioning that research on the teaching and learning of natural sciences and technology is still a fledgling, leaving educators with a knowledge gap that inhibits success in that field. Indeed, the results from different authors show that there are challenges in enhancing science learning and SL through ICT strategy.

1.4 South African Curriculum Policy on science learning and promoting SL

Within South Africa, the post-apartheid democratic government has been constantly revising and improving the school syllabi in science learning and SL. The National Curriculum Statement (NCS), Revised National Curriculum Statement (RNCS) and the CAPS are examples of this constant effort to learn from previous mistakes and to take the concern constructively forward. Furthermore, the CAPS document has included specific aims for each phase. This research focuses only on grade 9 in the senior phase (Grades 7, 8 and 9).

1.4.1 The specific aims of CAPS natural science syllabus

In order to go deeper in the natural science curriculum, three specific aims in natural sciences are emphasized in CAPS by the Department of Basic Education or DBE (2011c:10) Senior Phase and these are:

Specific aim 1: "Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions. Learners plan and do simple investigations and solve problems that need some practical ability. Attitudes and values underpin this ability. Respect for living things is an example – learners should not damage plants; if they examine small animals they should care for them and release them in the place where they found them".

Specific aim 2: "Knowing the subject content and making connections'
Learners should have a grasp of SL, technological and environmental knowledge and be able to apply it in new contexts. The main task of teaching is to build a framework of knowledge for learners and to help them make connections between the ideas and concepts in their minds – this is different to learners just knowing facts. When learners do an activity, questions and discussion must follow and relate to previously acquired knowledge and experience, and connections must be made".

Specific aim 3: **"**Understanding the uses of Science'**:** Learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment. Science learnt at school should produce learners who understand that school science can be relevant to everyday life. Issues such as improving water quality, growing food without damaging the land and building energy-efficient houses are examples of applications. An appreciation of the history of SL discoveries, and their relationship to indigenous knowledge and different world views, enriches our understanding of the connections between Science and Society".

These three specific aims are linked with the contents in natural science curriculum. The Natural Science Curriculum at the Senior Phase is based on four knowledge strands namely, Life and Living, Matter and Materials, Energy and Change and Planet Earth and Beyond. The Department of Basic Education (2011c: 9) states that:

> Each knowledge strand is developed progressively across the three years of the Senior Phase. The Knowledge Strands are tools for organizing the subject content. When teaching Natural Sciences, it is important to emphasize the links learners need to make with related topics to help them achieve a thorough understanding of the nature and connectedness in Natural Sciences.

The educators' task is to make it a point that the lesson compiled connects with the specific aims and meets the learners' needs. For example in Life and Living when teaching about photosynthesis, the learners must investigate first, observe the experiment and make connections with the content given by the educator.

Furthermore, educators must be aware of the instructional time in the Senior Phase which is three hours. That means both theory and practical work are accomodated in these hours.

1.4.2 Factors in science learning and promoting SL that are subsumed under CAPS specific aims

According to the DBE (2011c:10) there are factors that are included under CAPS specific aims and they play an important role in enhancing science learning and promoting SL. The following are adapted from CAPS for senior phase.

1.4.2.1 Process skills

The teaching and learning of Natural Sciences (NS) involves the development of a range of process skills that may be used in everyday life in the community and in the workplace. Learners also develop the ability to think objectively and use a variety of reasoning while they use these skills. Learners can gain these skills in an environment that taps into their curiosity about the world, and that supports creativity, responsibility and growing confidence. The following are the cognitive and practical process skills that learners will be able to develop in Natural Sciences: accessing and recalling information, observing, comparing, measuring, sorting and classifying, hypothesizing, planning and doing investigations as well as recording, interpreting and communicating informaton.

1.4.2.2 The SL Process

It is a way of investigating things about the world. Scientists use this process to find out about the world and to solve problems. The steps that make up the SL process are not necessarily in order (sequential), and may include identifying a problem and developing a question, forming a hypothesis, designing an activity or experiment, observing/noting changes/reactions (e.g. through measuring), and making inferences about the observations recorded in the tables, graphs.

1.4.2.3 Developing language skills: reading and writing

The ability to read well is central to successful learning across the curriculum. Writing is also a powerful instrument of communication. Writing allows learners to construct and communicate thoughts and ideas coherently and this is essential to develop science learning and promote SL among learners and to empower them to communicate and contribute to society as science literate persons.

1.4.2.4 Resources

CAPS lists the resources needed for teaching Natural Sciences against each topic in order to assist educators with planning and preparation. The list is a guide and suitable alternative tools and materials may be used.

1.4.2.5 Strategies

All the strategies for science teaching are significant, but the present researcher selected only three strategies for the study which are: science inquiry, Predict-Observe-Explain strategy (POE) and information and communication technology (ICT). These strategies also link with the policy document for natural science CAPS document (2011 c: 10).

1.4.2.6 CAPS specific aims, science learning and promoting SL and science inquiry strategy

Science inquiry links with Specific aim 1 by stating that : (a) Learners should be able to complete investigations, (b) analyse problems, (c) use practical processes and skills in evaluating solutions, (d) plan simple investigations, (e) do simple investigations and (d) solve problems that need some practical ability. Besides these activities, the specific aim 1 also emphasises attitudes and values that underpin these abilities. An example cited in the specific aim in this regard is the respect for living things (learners should not damage plants; if they examine small animals they should care for them and release them in the place where they found them). Therefore, during inquiry skills in promoting science learning and SL, there is a merger of practical activity and skills with attitudes and values. As such, a science literate person is just not skilled but also has the positive attitude and values embedded with responsibility to nature and other living beings.

Science inquiry links also with Specific aim 2, that is, knowing the subject content and making connections in that (a) learners should have a grasp of SL, technological and environmental knowledge and (b) be able to apply it in new contexts. This aim guides educators by stating that the main task of teaching is to build a framework of knowledge for learners and to help them make connections between the ideas and concepts in their minds – this is different to learners just knowing facts. When learners do an activity as part of SL inquiry (Specific aim 1), questions and discussion must follow and relate to previously acquired knowledge and experience, and connections must be made. Questions and discussions promote the interconnectedness necessary to enhance science learning and SL.

Science inquiry links also with Specific aim 3 which alludes to understanding the uses of Science and specifies that (a) learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment, (b) science learnt at school should produce learners who understand that school science can be relevant to everyday life. Examples cited are issues and applications such as improving water quality, growing food without damaging the land and building energy-efficient houses. An appreciation of the history of SL discoveries, and their relationship to indigenous knowledge and different world views ought to enrich the understanding of the connections between Science and Society.

As such, CAPS also notes that science learnt at school should produce learners who understand that school science can be relevant to everyday life. The reference to indegenous knowledge is also pertinent as there is a wide variety of useful indigenous knowledge in Africa in general and South Africa in particular. Links to indigenous knowledge during teaching and during inquiry activities are considered as significant ways to relate to society. All the aspects under inquiry have interconnectedness and they link with the former two natural science specific aims in the CAPS document.

1.4.2.7 CAPS specific aims, science learning and promoting SL and Predict-Observe-Explain instructional strategy

Science learning and promoting SL ought to consist of science inquiry skills as explained in the previous sub-section. Inquiry demands that the learners must be able to predict, observe and explain. For instance, under process skills in CAPS (DBE, 2011) learners are expected to (a) identify a problem and develop a question, (b) form a hypothesis, (c) design an activity or experiment, (d) observe/note changes/reactions (e.g. through measuring), and (e) make inferences about the observations recorded in the tables, graphs. A range of activities as well as mental challenges for logical thinking are part of this strategy as the components (a) to (e) demand these.

1.4.2.8 Science learning and promoting SL and information communication and technology (ICT)

According to Luu and Freeman (2011) recent studies show that the methodology of using ICT in teaching has strong impacts on science learning and promoting SL level of the learners. The strategy is chosen to see if the educators implement the content integrating technology since it is the current trend. Anderson (2010) notes that the use of ICT provides opportunities of quick search and assist in information retrieval in a well-organized method.

1.5 Statement of the problem

Studies on SL which were carried out in several countries such as America, Canada, South Korea, Malaysia, Thailand, Turkey, Indonesia, Nigeria and South Africa have already been cited in the previous sections. However, these studies which could be located were not done with a focus on promotion of SL in rural schools. There were two studies in South Africa that could be located, one by Habteselassie (2015) in city high schools and the other by Bantwini (2017) in rural primary schools. Both the studies were focusing only on science inquiry skills. As such, the problem is that there is no study in the senior phase (Grade 7-9) in rural schools in South Africa's Eastern Cape which reported on the strategies employed by educators in promoting science learning and SL for grade 9 leaners. This study was carried out to solve that problem.

1.6 Rationale

The TIMSS (2015) report on ninth grade learners' achievement claims that the environment of learning remains generally poor, the school climate must be improved for effective teaching and learning. (Reddy, Visser, Winnaar, Arends, Juan, Prinsloo & Isdale, 2015). Responding to the call this research presents the model that teachers can use to promote science learning and science literacy.

1.7 Purpose of the study

The purpose of the study is to examine educators' strategies for promoting science learning and SL among grade 9 learners in a rural education district.

1.8 Research Questions

1.8.1 Main Research Question

Which educator strategies are the most effective in promoting science learning and SL among Grade 9 learners in a rural education district?

1.8.2 Sub-Research Questions

a) Which strategies do educators use to teach Natural Science curriculum?
b) What are the strengths and weaknesses of these strategies in promoting science learning and SL?
c) How are educators supported in promoting science learning and SL?
d) Which strategies are deemed relevant in promoting science learning and SL?
e) How do educators assess learners' science learning and SL?

1.9 Objectives of the study

The objectives are to :

a) ascertain the strategies used by educators to teach natural science curriculum.
b) establish the strengths and weaknesses of these strategies to promote science learning and SL.
c) find out how educators are supported to promote science learning and SL.
d) find out which strategies are deemed as relevant in promoting science learning and SL

e) establish how educators assess learners' science learning and SL.

1.10 Research Methodology and plan of action

Table 1-1: An outline of the research plan of action. The details are given in chapter

Guiding Research question	
Which educator strategies are the most effective in promoting science learning and SL among Grade 9 learners in a South African rural education district?	
Paradigmatic Suppositions	
Epistemological Models:	Paradigm: Pragmatic paradigm that combines both positivism and interpretivism
Methodological Model: combining QUAN and QUAL methods	Approach: Mixed method research approach
Research design	Concurrent triangulation design
Sample and sampling procedures Convenience sampling for selection of education districts, circuits, schools, Grade 9 science educators and purposive sampling for selection of learners.	Number of education disctrict was one and the number of circuits were six out of eight. The number of schools in the sample was 30 Number of Grade 9 science educators in sample was 30 out of a population of 67. Number of learners in the sample was 30 Grade 9 learners, three per school, divided into 10 focus groups, each with three learners.
Data collection:	
Data collection methods for educators: Structured questionnaires, semi-structured interviews and participant observations.	Procedures for data collection: Questionaires were hand-delivered to science educators. One-to-one interviews with 10 Grade 9 science educators. Participant observations of 10 science classrooms.
Data collection methods for learners:	Focus group interviews with learners.

Data analysis and interpretation	
Data analysis method: Quantitative; Using Statistical Package for Social Scienes (SPSS) version 21	Descriptive statistics was used.
Data analysis method: Qualitative – Thematic approach was used	Thematic content analysis was used.
Validity and reliability and data trustworthiness	
Reliability	Chronbach's Alpha coefficient was used
Validity	
Data trustworthines	The following procedures were followed: Dependability, credibility, transferability and confirmability.
Ethical considerations	Permission was sought from the Provincial office of Department of Basic Education. Permission letter was forwarded to the district office and the principals of the schools. Anonymity was guaranteed for all the participants in schools. Ethical clearance from the university was sought and obtained. All the participants signed informed consent forms.

1.11 Significance of the study

Recommendations from the study will help the Department of education, district officials, curriculum developers and subject specialists to identify the strategies that will promote science learning and SL in junior secondary schools in general and Grade 9 in particular. Subject specialists will be able to provide relevant advice to implement Natural Science curriculum.

1.12 Limitations of the study

The study targeted only grade 9 educators and learners in 30 rural junior secondary schools at one rural education district in the Eastern Cape Province of South Africa and hence the results are not generalisable.

1.13 Operational definition of terms

Natural Science: The Collins English Dictionary (2009) defines it as a science or knowledge of objects or processes observable in nature such as biology, chemistry and physics. In this study Natural Science refers to a subject in the SA education system in which learners learn combined science

Natural science: It is any of the sciences (physics chemistry, biology) that deal with matter, energy, and their interrelations and transformations or with objectively measurable phenomena.

Science learning and promoting SL: The United States Centre for Education Statistics (2005) defines science learning and promoting SL as "the knowledge and understanding of SL concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity." In this study science learning and SL are described as the mastery of SL concepts and processes and the ability to apply them to solve problems.

Predicting: A prediction is a statement about a future event or a possible outcome, based on prior knowledge, collected data or some hypothesis. It means a hypothesis or educated guess about the outcome or future of something. It involves thinking ahead while reading and anticipating information and events in the text.

Recording: It is a procedure whereby the teacher write the level of learners perfomance in a particular task. It may also involve the learner in recording in a prescribed form (sentences, lists, tables, labelled diagram), selecting a suitable form to record the information when asked to do so, knowing when it is important to record, and doing so without being prompted by the educator, CAPS (DBE, 2011).

Experiment: Experiment is about "doing something to see what happens" Gega (1994:83). Experiment is an investigation process to test cause and effect.

Teaching Strategies: Akdeniz (2016) explains that teaching strategies are also called instructional strategies. Instructional strategies point to ways and approaches followed by educators to achieve the aims of instruction with intent to apply the knowledge and achieve the objectives successfully (Akdeniz, 2016). The concept will be used as the study is looking for the strategies used by educators for teaching science and promoting SL.

1.14 Thesis outline

This thesis is organized into five chapters as follows:

CHAPTER ONE: Introduction and Background followed by statement of the problem, purpose of the study, research questions, research objectives and research strategy study plan.

CHAPTER TWO: Review of literature related to the study based on research questions and includes: the concept science; making science teaching effective; strategies used by the educators to teach natural science curriculum; educator support for science learning and promoting SL; classification of instructional strategies; strategies relevant in enhancing science learning and SL; assessment for science learning and promoting SL; previous studies on science learning and promoting SL and lastly theoretical frame work.

CHAPTER THREE. Research Methodology including research paradigm, research approach, research design, and sampling, instruments and reliability and validity, data collection and data analysis.

CHAPTER FOUR. Data Presentation and Analysis.

CHAPTER FIVE: Discussions, conclusions and recommendations.

1.15 Summary

This chapter explained the background of the study looking at international, African and South African contexts. Theoretical frame work, research questions, purpose of the study, statement of the problem, significance of the study and delimitations of the study were covered in this chapter. The next chapter highlights the literature review relevant to the study.

CHAPTER TWO

THEORETICAL FRAMEWORKS AND LITERATURE REVIEW

2.1 Introduction

Chapter one introduced the study and the background of SL and strategies to promote it. This chapter covers the theoretical framework. The main theoretical framework for the study is constructivism which subsumes cognitive constructivism and social constructivism. Shulman's pedagogical content knowledge (PCK) was added to cater for educators' understanding about the content and how to transfer the content knowledge to learners. It also deals with how to help learners understand á specified subject. This chapter also presents related literature under the following topics: science learning and SL, making science teaching effective and promoting SL, strategies used by educators to teach natural science curriculum promoting science learning and SL, some of the strategies used by educators, strengths and weaknesses of the strategies, educator support for science learning and promoting SL, classification of strategies, strategies relevant in enhancing science learning and promoting SL and assessment of science learning.

2.2 Theoretical framework

Theoretical framework provides the structure that will guide or support the research study and assist in understanding of the phenomenon under the study. McGaghie, Bordage and Shea (2010) and Mtsi (2015) observe that the theoretical framework always underlies a research study. According to Taber (2011) science education has been strongly influenced by constructivist thinking. This study will be informed by the constructivism theory which subsumes cognitive constructivism and social constructivism.

2.2.1 Cognitive constructivism

Piaget mentioned the different stages of cognitive development which are : sensorimotor stage (0-2 yers), preoperational stage (2-7 years), concrete operational stage (7-11 years) and formal operational stage (11+ years). In South Africa, learners enrol in Grade 1 after completing 6 years and those in Grade 9 ought to be ideally around 16 years. As this research is dealing with Grade 9 learners, only the formal stage is relevant in this study. Abstract thought and hypothetical reasoning mark this phase of development. It is at this point that thinking becomes sophisticated and advanced. At this stage, intelligence is demonstrated through the logical use of symbols related to abstract concepts. Piaget's theory of constructivism argues that people produce knowledge and form meaning based upon their experiences. There are two key components which create the construction of an individual's new knowledge: assimilation and accommodation. Assimilation is the process of taking new information in one's environment. Accommodation occurs when new experiences are interpreted to fit into the earlier ideas and achieve integration (Piaget, 1962). It occurs when humans are faced with new or unfamiliar information and refer to previously learned information in order to make sense of it. Piaget recommended that educators must take an active, mentoring role toward learners, share the learning experience, encourage learners to be active and engaged and respect their ideas, suggestions or opinions. Furthermore, the author suggests that educators must supplement traditional lectures with relevant, hands-on classroom activities that let learners experience the content for themselves. Piaget's theory is also commonly labelled as Cognitive Constructivism and it emphasises the active role of the learner and the significance of current (i.e. pre-existing) knowledge and understanding in mediating learning, as well as the importance of teaching that provides an optimal level of guidance (Taber, 2011). Allen (2014) also stresses the role of accommodation.

Piagetian accounts of development has been challenged on several grounds. Firstly, as Piaget himself noted, development does not always progress in the smooth manner as his theory seems to predict. Secondly, studies have found that children may be able to learn concepts and capability of complex reasoning that are supposedly represented in more advanced stages with relative ease (Lourenco & Machado, 1996). Piaget's theory has been said to undervalue the influence that culture has on cognitive development. Moreover some scholars question whether the stages of development are real. Piaget's data collection method is deemed subjective because he conducted the observation alone. Cherry (2016) mentioned that much of the criticism of Piaget's work is with regard to his research methods. In addition to this, the other children in

Piaget's small research sample were all from well-educated professionals of high socio-economic status. Because of this unrepresentative sample, it is difficult to generalize his findings to a larger population. However, Cherry (2016) also supports Piaget’s theory by stating that Piaget's focus on qualitative development has an important impact on education . In addition to this, a number of instructional strategies have been derived from Piaget's work. These strategies include providing a supportive environment, utilizing social interactions and peer teaching, and helping children see fallacies and inconsistencies in their thinking. The classroom is no longer a place where the educator is talking alone and learners treated as empty vessels. The educator is a facilitator who helps learners to use their critical thinking.

2.3 Vygotsky’s social constructivism

Vygotsky’s (1896-1934) social constructivism emphasizes thát social context (the importance of culture and environment on the learning process) is pertinent. The theory assumes that reality is constructed through human activity and knowledge is created through interactions with others, and their environment and learning is more meaningful when learners are socially engaged. Critical thinking is needed and the educator (more knowledgeable) is expected to assist the learner (less knowledgeable) to reach the expected level. Vygotsky highlighted the Zone of Proximal Development (ZPD) which is central to Vygotsky's view on how learning takes place. He described this zone as the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. Vygotsky (1896-1934) maintained that learning occurs just above the student's current level of competence. Figure 2.1 shows the zone of proximal development.

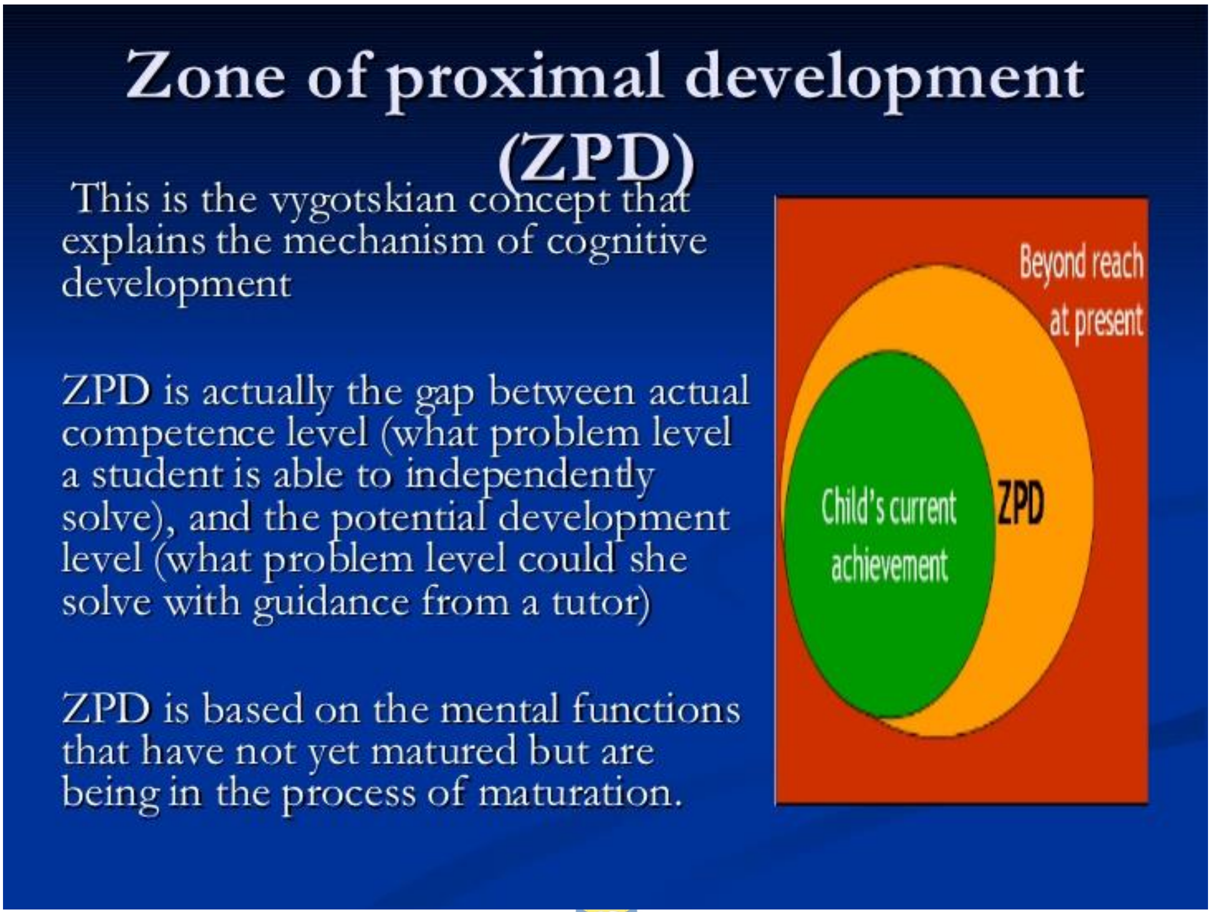


Figure 2-1: adapted from: https://www.google.ca/search

Elaborating on learning as social process, Vygotsky (1896-1934) maintained that learning is a necessary and universal aspect of the process of developing culturally organized, specifically human and psychological functions. In terms of learning as an active process, the educator has the collaborative task of guiding and directing the learners' activities. Learners can then solve novel problems on the basis of a model shown in class. Learning is also done in a cultural context. The main theory that underpins cooperative learning refers to social constructivism advanced by Vygotsky. He considered the roles of culture and society as well as language and interaction as important in understanding how humans learn. Vygotsky (1896-1934) assumed that knowledge was cultural and took a socio-cultural approach in his study with children. This approach can be briefly described as "cooperative" and "cultural." Vygotsky (1896-1934) asserted that the development of individuals, including their thoughts, languages and reasoning processes, is a result of culture. These abilities are developed through social interactions with others (especially parents and educators) and therefore, they represent the shared knowledge of a given culture. Vygotsky

(1896-1934) maintained that language played a central role in cognitive development. He argued that language was the tool for determining the ways a learner learned "how" to think. That is because complex concepts are conveyed to the child through words. Learning, according to Vygotsky, always involves some type of external experience being transformed into internal processes through the use of language. It follows that speech and language are the primary tools used to communicate with others, promoting learning.

On the role of the educator, Vygotsky defines those who teach as the "More Knowledgeable Other" abbreviated as MKO. An MKO is anyone who has a better understanding or a higher ability level than the learner, particularly with regard to a specific task, concept or process. Traditionally the MKO is thought of as an educator or an older adult. However, this is not always the case. Other possibilities for the MKO could be a peer, sibling, a younger person, or even a computer. The key to MKO is that they must have more knowledge about the topic being learned than the learner does. Educators or more capable peers can raise the student's competence through ZPD. In Vygotskian perspective, the ideal role of the educator is that of providing scaffolding (collaborative dialogue) to assist learners on tasks within their ZPD. During scaffolding, the first step is to build interest and engage the learner.

Zhu, Ennis and Chen (2011) identify some key features of constructivist theory of learning such as the learner being actively engaged in learning, the learner’s experiences being important in learning and the learner personally constructing meaningful understanding of concepts. Learners’ experiences count because each learner is not an empty vessel and learners are capable of constructing meaningful understanding of concepts personally and also through social interaction with educators and peer learners. Both the cognitive and social perspectives are relevant in science learning and promotion of SL since it not only involves individuals and their prior knowledge but also their nurture and social interactions.

2.3.1 Implication of the constructivist theories for the present study

There are similarities in both cognitive and social constructivist theories. Both recognize the value of each learner, considering the experience they already had and how it is linked with the new information they receive in school in order to make sense of it. Both encourage educators to promote learners' critical thinking and active participation in the classroom and cater for all learners. Both theories mention team work and collaboration to promote teaching and learning. When learners assist each other, it is easy for them to understand. Vygotsky in his theory emphasizes the zone of proximal development whereby the knowledgeable one must assist the learners in order to reach the level expected while Piaget on the other hand emphasizes guiding the learners, with the educator expected to share the learning experience and encourage learners to be actively engaged in the lesson. The educators must also supplement teaching with hands on activities. In view of the specific aims and science teaching strategies explained in the foregoing sections, it is clear that promotion of science learning and SL can only be fruitful by applying the cognitive and social learning theories, highlighting their relevance to the present study.

Concerning this study, the learners need to be assisted in science processes in order to learn science and promote SL. They can be assisted by their peers or an adult. Figure 2.1 on ZPD gives a picture of what the learner can achieve alone, or what the learner can achieve with the assistance of the more knowledgeable or peer. ZPD is significant for educators to apply when teaching science. For instance experiments and concepts are tricky sometimes and they need clarification and support from the educator. When the learner cannot achieve the task, anxiety affects the progress in learning. Immediately when the educator or peer offers assistance, the learner feels confident and the attitude becomes positive leading to effective learning. There are strategies that can be employed by science educators to involve learners. In other words, learners learn by solving problems with the help of the educator, who models processes for them in a classroom environment that is directed by the educator. In essence, the learner imitates the educator through a process of re-creating previous knowledge. It is important for the educator not to control the class with rule and structure; rather, the educator collaborates with the learners and provides support and direction. The strategies that can be employed by science educators include the three models which promote active learning: Generative model emphasizes some phases of learning such as focus phase which deals with engaging students more in a lesson. Another phase is challenge phase which specifically looks at learners, comparing SL concepts with their own ideas.The second model is Interactive approach which is basically concerned with encouraging learners to be active, making use of experiments as the study focuses on promoting science learning and SL. Lastly, there is the Instructional model which focuses on learners' interest that promotes curiosity in learners. Once the learner is actively participating, the given task should be simplified by breaking it into smaller subtasks. During this task, the educator needs to keep the learner focused, while concentrating on the most important ideas of the assignment. One of the most integral steps in scaffolding consists of keeping the learner from becoming frustrated. The final task associated with scaffolding involves the educator modeling possible ways of completing tasks, which the learner can then imitate and eventually internalize.

2.4 Shulman Pedagogical Content Knowledge (PCK)

Shulman (1986:9) described pedagogical knowledge as a "particular form of content knowledge that embodies aspects of content most germane to its teachability". Shulman argues that content knowledge goes with pedagogy; if the two aspects are treated separately then educators will not benefit. The author further notes that if pedagogy is used alone it is likely to be useless without content (Shulman, 1986). Pedagogical content knowledge is an educator's understanding of how to help learners understand a specific subject (Magnusson, Borko & Krajcik, 1999). Magnusson, et al. (1999) further note that pedagogical knowledge (PCK) includes knowledge of how particular subject matter topics, problems and issues can be organised , represented and adapted to the diverse interests of learners' abilities and then presented for instruction. Shulman proposes the two types of knowledge (pedagogical knowledge and content knowledge) and states that at the intersection of the amalgamation lies pedagogical content knowledge (Shulman, 1987). Figure 2.1 below illustrates the three aspects of knowledge.

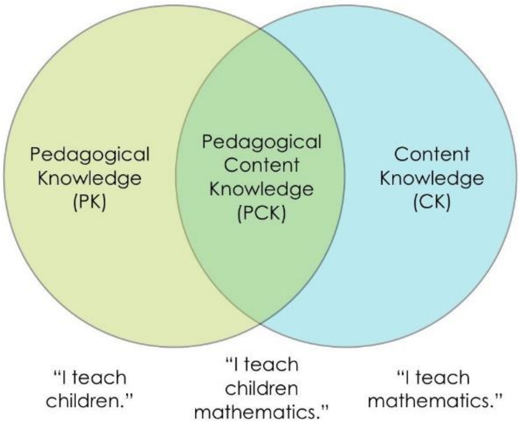


Figure 2-2: Shulman (1986) elaborated on the three aspects, i.e subject matter

2.4.1 Subject matter knowledge

Subject matter knowledge is the amount of organisation of knowledge in the educators' minds about the discipline (Shulman,1986). Schwab (1978) mentions that the subject matter involves understanding of the structure of the subjects, for instance it includes substantive and syntactic knowledge. While Shulman (1986) further highlights that subject matter knowledge goes beyond the knowledge of facts and concepts in the discipline.

2.4.2 Substantive knowledge

Shulman (1986) states that this type of knowledge involves knowing different ways in which the base concepts and principles of the discipline can be organised to incoporate its facts. Again the author explains how ideas are related or connected in a subject. The researcher's opinion with regard to the above is that in Natural Sciences the policy document mentions the information to be known by the learners. Then the educators must unpack the information by doing connections in terms of the pedagogy to be used, resources as well as how the society is going to benefit .

2.4.3 Syntactic knowledge

Schwab (1978) explains that this type of knowledge involves knowledge of the ways in which experts decide what constitutes legitimate SL knowledge in a field being investigated . These aspects of knowledge under syntactic are curricular knowledge and pedagogical content knowledge.

2.4.4 Curricular knowledge

Shulman (1986) opines that this type of knowledge includes both educators' knowledge of the different teaching programmes that are available to teach a particular topic and different instructional materials such as laboratories, textbooks, computer, software etc. Vygotsky puts emphasis on the importance of prior knowledge in the social constructivism.The present researcher's view regarding the NS is that educators must be well versed in the subject and the topic. Subsequently the educator must know the specific goals and objectives of the topic so that it can be easy to translate the NS curriculum. By understanding the curricular knowledge the educator will be able to teach NS to promote science learning and SL effectively and will not experience the challenges of enhancing the concept.

2.4.5 Pedagogical Content Knowledge (PCK)

PCK is described as representing the "blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented, adapted to the diverse interest and abilities of learners and presented for instruction" (Shulman 1987:8). It is the kind of knowledge associated with the teaching of specific topics and it goes beyond knowledge of subject matter (Shulman,1986). With regard to the above concept of going beyond knowledge of the subject matter, the researcher's view is that the NS knowledge must prepare the learners for the world of careers e.g doing periodic table in N.S grade 9 should help learners to focus on physics when they reach grade 10. Physics will provide the learners with chemistry knowledge which after matric enables them to take science related careers like pharmacy, laboratory science etc. Shulman (1986) states that an expert educator is able to teach effectively if that person has knowledge and understanding of :

- typical learning difficulties learners may encounter when learning the particular topic.
- the likely preconceptions and misconceptions
- strategies needed to represent that particular content so that learners can understand.

This implies that an expert NS educator must have curriculum, content and pedagogical knowledge that assist on how to transfer the knowledge to learners in a meaningful way. Again when the learner is encountering challenges in the topics, it is the educators' duty to check the learners' prior knowledge and link it with the new information. After that learners must be given an opportunity to give feedback by critiquing the topic. Then the critiques can assist the educators to clarify misconceptions. The educator will subsequently be able to develop relevant strategies for teaching the topic effectively.

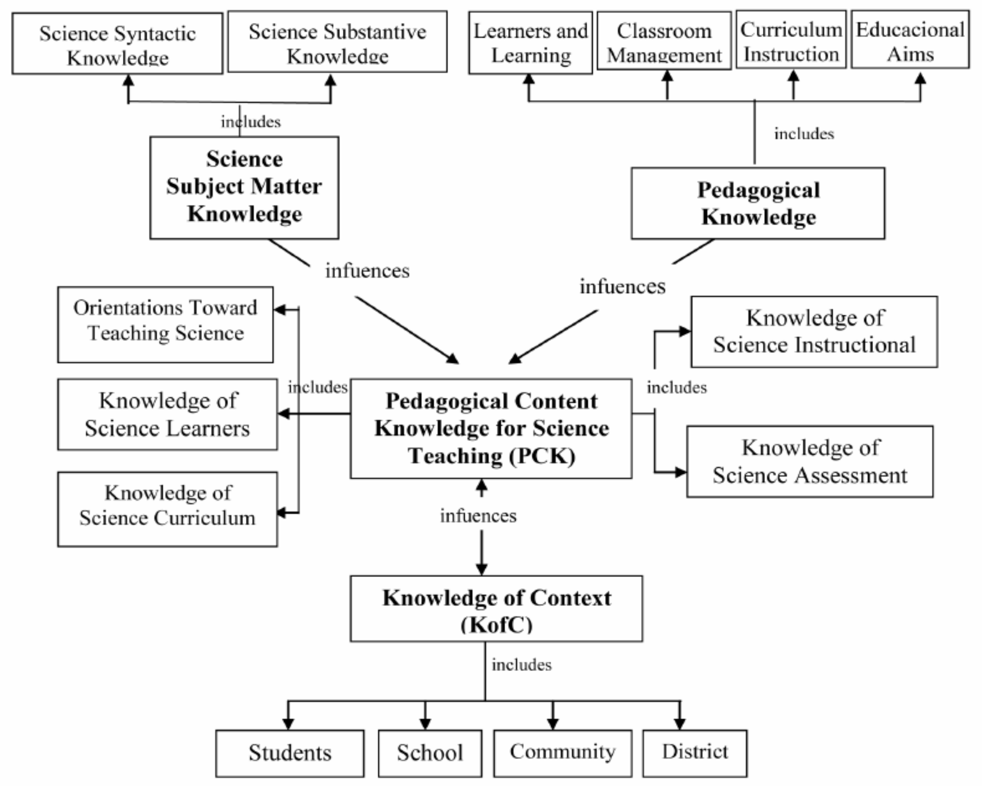


Figure 2-3: Shulman pedagogical content knowledge (1986)

The present researcher's interpretation of the diagram is as follows: To have content knowledge means an educator is supposed to have subject matter, curricular knowledge about the subject and pedagogies of the content. When you have good content knowledge it is easy to critically analyse things concerning curriculum. For example, firstly, you are able to identify learning difficulties in the topics or in the course outline. Secondly, misconceptions can be clarified and relevant resources are chosen based on the backgound of the learners.

2.4.6 Critics of PCK

Literature shows that there are authors who criticize PCK. For instance, Grossman, et al. (1989) modified Shulman's construct of PCK by identifying four categories of knowledge which constitute pedagogical content knowledge about teaching a particular topic that is: (a) knowledge about the purpose of teaching (b) knowledge about learners' understanding (c) curricular knowledge and (d) knowledge about instructional strategies and representation. Cochran (1993) modified Shulman PCK construct to pedagogical content knowing (PCKg), justifying the reason for the modification as, in constructivism knowledge growth is an active and an ongoing process. While Gess – Newsome (2015) critique by saying that the teaching process and the influence of educators' knowledge in the process have proved to be a difficult exercise and the author has also come up with suggestions of another model e.g organisation of knowledge, intergration of previously disjoined data, suggestions of explanations, stimulation of research and revelation of new relationships (Gess-Newsome, 1999).

Sanders (2008) also modified Shulman's model and formed his model in three ways. Sanders mentioned that Shulman's category of subject matter knowledge was added as a sub-category to PCK. Sanders (2008) highlights that this is not necessary because PCK is about knowledge of matters associated with the teaching of a particular topic and in order to teach any topic, educators must have knowledge of the subject. Again Sanders included Shulmans category of curricular knowledge as a sub-category under pedagogical content knowledge because curricular knowledge about the topic is very important for teaching. However Shulman's curricular knowledge is under content knowledge. Sanders (2008) further expanded the sub-category of learning difficulties by including difficulties that educators may encounter when teaching evolution. The last critique by Mavhunga (2014) is that PCK differs seriously between topics and they need to be measured at the topic specific level. Mavhunga further mentions that his model is drawn from educators' ability to transform the context specific topics into teachable form. Mavhungas' model is not a stand alone model, it is based on Shulmans idea (Shulman, 1987:16) that "comprehended ideas must be transformed in some manner if they are to be taught.'' There are five components used in Mavhunga's model (Mavhunga, 2014):

- Learners' prior knowledge including misconception
- Curricular saliency
- What makes a topic easy or difficult to understand
- Representation including analogies
- Conceptual teaching strategies

Mavhunga (2014) explains that these components have a content specific orientation to CK, requiring specific considerations to be made about CK. Mavhunga (2014) further mentions Topic Specific Pedagogical Content Knowledge (TSPCK) as a theoretical construct which is defined as the capacity to transform a specific topic through the five content specific components. Hence, measurement of PCK using this model implies measuring each of the five components by topic.

2.4.7 Justification of using Shulman theory (PCK)

The present researcher views PCK as relevant for the study. The reason is that the study will be looking more on the strategies that will promote science learning and SL. However, the researcher will consider the strategies applied by Natural Science educators during lesson observations and critically evaluate if the educators under scrutiny are able to identify learners' learning difficulties. Lastly, the researcher will also find out if all sampled educators have knowledge of teaching strategies as suggested by Shulman's theory.

Piaget's cognitive constructivism theory links with Shulman's theory in the sense that both highlight learners' active involvement in the generation of their own knowledge. When actively involved learners are able to reason hypothetically and deductively.This enables them to hypothesise for a certain situation. Definitely when they do hypotheses they are engaged in science inquiry strategy . Piaget also motivates educators to encourage learners to be active and educators must supplement traditional lectures with relevant hands-on classroom activities. To add to the above statement, Shulman opines how each topic should be taught, that is educators must consider learners' prior knowledge with the interconnectedness of the topic. This means when considering the prior knowledge it can be done in various ways either practical or as a written task.

Vygotsky (1978) also emphasizes that learning as an active process simply means that educators must actively involve learners in the teaching and learning of NS. Vygotsky (1978) also mentions that learning is done in a cultural context; that is the theory underpinning co-operative learning. Vygotsky (1978) states that knowledge is cultural in the sense that the development of individuals including their thoughts, languages and reasoning processes is a result of culture. Therefore, this research is of the view that , despite critiques of the PCK, the theory is of relevance for this researcher's study. Shulman emphasizes that there are relations between subject matter, content knowledge and pedagogical knowledge.The researcher will also use some of the components from Mavhunga model since the components stress the importance of learners and prior knowledge which is an element that makes a topic easy or difficult for the learners.

2.5 Science learning and SL

Science education aims to prepare learners for a career in science and technology (pre-professional training) NSTA (2009). NSTA (2009) notes that through science, learners are equipped with practical knowledge and skills for science learning and promoting SL in order to become literate people who are able to resolve day to day scientific and life issues. Naumescu (2008) and NSTA (2009) mention that an educator when implementing science must be able to create new ideas and integrate science with technology, environment and society in a global perspective. These are indeed the elements of SL. Educators must present the science curriculum in way that develops students' curiosity (Naumescu 2008 & NSTA 2009) so that they will be able to understand science and apply the skills independently both in the society and their science careers.

The South African Department of Basic Education (2011c) Senior Phase policy document (CAPS) aligns itself with the NSTA principles. According to CAPS, science is a systematic way of looking for explanations and connecting ideas. In Science, certain methods of inquiry and investigation are generally used. These methods lend themselves to replication and a systematic approach to SL inquiry that attempts at objectivity. CAPS indicates formulating hypotheses as well as designing and carrying out experiments to test the hypotheses, among others, as part of scienctific inquiry and to promote SL. Repeated investigations are undertaken, and the methods and results are carefully examined and debated before they are accepted as valid. Natural Sciences at the Senior Phase level lays the basis of further studies in more specific science disciplines, such as Life Sciences, Physical Sciences, Earth Sciences or Agricultural Sciences. Science learning and promoting SL is of utmost importance since it will catalyse preparation of learners for active participation in a democratic society that values human rights and promotes responsibility towards the environment. SL also prepares learners for economic activity and self-expression.

2.6 Making science teaching effective and promoting science literacy

Effective teaching is necessary both for understanding science and for promoting SL. According to Coe, Aloisi, Higgins and Major (2014), effective teaching improves student achievement. Pedagogical content knowledge is a strong evidence of the impact on student outcomes (Coe, et al. 2014). Other important variables that influence effective teaching are classroom climate, classroom management, quality of instruction, educator beliefs and professional behaviours (Coe, et al. 2014). However, they also highlighted that while some of the above variables have moderate outcomes, others have strong outcomes. Coe, et al. (2014) emphasize that in order to achieve the successful implementation of the curriculum that supports pedagogy, educators must be the experts in these: professional competence, subject matter content knowledge and pedagogical content knowledge. Moreover they mention that these three competencies are interrelated to one another.

2.7 Strategies used by educators to teach natural science curriculum in promoting science learning and science literacy

There are different strategies such as: metacognitive strategy, science inquiry, Information communication and technology strategy, concept mapping, co-operative learning, discovery method, generative instructional strategy and Predict-Observe-

Explain strategy (Miranda, 2012; Nindiasari, 2011; Hiang, 2005; Ibe-Bassey, 2011; Youssef & Mohammed 2016). All these strategies are imperative in science teaching and they have a role to play in science classroom setting.

2.7.1 Metacognitive

Oneil and Brown (1997) define metacognitive as the process of thinking about their own thinking in order to develop strategies to solve problems. Miranda (2012) and Nindiasari (2011) agree that the use of this strategy enhances learners' thinking skills.

2.7.2 Science inquiry

The term inquiry is defined as investigation of a problem, finding the truth or knowledge that requires thinking critically, analytical thinking, making observations, asking questions, doing experiments and stating conclusions (Hiang, 2005; Aji & Budiyono, 2018). Wang and Wen (2010) explain that in the inquiry – based approach learners benefit e.g. they gain better understanding of content and ability to think critically and creatively. It means science inquiry promotes constructivism.

2.7.3 Information and Communication Technology (ICT)

Information and communication technology is regarded as a critical tool for preparing and educating learners with the required skills for the global work place (Ibe-Bassey, 2011). Using technology tools to integrate science teaching and learning provides educators with opportunities to reach primary source learning materials, utilizing new methods to collect and record data, communicate and share learning experiences (Eady & Lockyer, 2013).

2.7.4 Concept Mapping

Concept mapping is a two dimensional representation of the relationship between key ideas (Youssef & Mohammed, 2016). The principle of concept map is to provide visual means of showing connections and relationships between hierarchies of ideas ranging from the very concrete to the abstract (Youssef & Mohammed, 2016).

2.7.5 Co-operative Learning

Youssef and Mohammed (2016) define co-operative learning as an instructional strategy which organises learners in small groups so that they can work together to maximise their own and each other's learning. Furthermore, the authors reveal that aspects used in science subjects like critical thinking, reasoning and problem solving are promoted in this strategy.

2.7.6 Discovery Method

Discovery Learning is a method of inquiry-based instruction used for learners to discover facts and relationships for themselves (Bruner, 1961). The author also mentions that learners interact with the world by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. Bruner's theory encourages active engagement, promotes motivation, autonomy, responsibility, independence, creativity and problem solving skills.

2.7.7 Generative instructional strategy

Marzan Centre Staff (2014) notes that generative and test hypotheses is a strategy that demonstrates to learners how to make claims and support them with evidence. Furthermore in this strategy there are aspects that can benefit the science learners such as: investigation, problem solving and decision making (Marzan Centre Staff, 2014).

2.7.8 Predict-Observe-Explain instructional strategy

In this strategy learners do not simply make connection between the content being taught. Their prior knowledge which is very important also needs to be re-organised to make it meaningful (Wittrock, 1992). It is the strategy that deals with experiments, whereby students are involved in practical tasks following specific procedures.

2.7.9 Some of the strategies used by educators that are useful in promoting science learning and science literacy

Several researchers have reported on the strategies, their strengths and weaknesses in science learning and SL (Gatawa,1990; Leemkuil, Jong & Ootes, 2000; Anaekiwe, Nzelum, Olisakwe & Okpala, 2010; Zajkov & Mitrevski, 2012, Ekeyi, 2013; Sumarni, 2013; Keller, 2016; Achimugu, 2018; Aji & Budiyono, 2018; Sunbul, 2018; Zulfiqar, et al. 2018.) as presented below:

2.7.9.1 Demonstration

Demonstration refers to the teaching strategy whereby the educator is the principal actor and learners watch in order to participate later (Ekeyi, 2013). Achimugu (2018) explains that demonstration is a strategy that can be improved if it is experimental by involving learners through questions, brainstorming and debates. The present researcher defines demonstration as the strategy that develops the learner holistically, lends ability to think critically from what the educator has demonstrated and link it with the real experiences. The strategy also promotes the use of different learning styles whereby learners can observe and participate using pictures to explain science concepts. Therefore, the present researcher echoes the same sentiments with Achimugu (2018) that demonstration can be successful if it promotes active engagement while allowing students to think logically to solve the problem. The disadvantage of the strategy is that it can be time consuming during the practical activities, especially when not well monitored.

2.7.9.2 Simulation

Simulation is a strategy designed by a constructivist theory (Vygotsky, 1978). It is a strategy which offers students learning-based experience that inspires and encourages them to learn. Furthermore it offers students information-rich environment where they work, collaborate, brainstorm and share their ideas as well as make decisions in certain situations while working in the risk-free but practical environment (Zulfiqar, et al. 2018). The present researcher defines simulation as the strategy that enhances practical work through the use of technology to improvise in the case where there is a shortage of laboratory resources. It gives a clear picture of an experiment, while students are observing, assimilating the new knowledge.

The advantage is that, it is risk free since there are no electric wires or chemicals to be touched. Teaching and learning can progress smoothly, there will be no complaints from the side of the educators about not teaching a certain section because of the lack of resources. In simulation system, there is a set of rules which students need to follow giving them an impression of working in a real-based but risk free scenario (Leemkuil, Jong, & Ootes, 2000). Different authors voiced out the lack of special-needs, shortage of educators eager to provide their time and expertise and educators' poor teaching practices that may have a negative effect on the simulation process (Billingsley & Scheuermann, 2014; McPherson, Tyler-Wood, Mcenturff, & Peak, 2011). In support of the above mentioned views, Girod and Girod (2008) reveal that educators need an ever-growing set of knowledge, skills and attitudes to meet their accountabilities.

2.7.9.3 Project

Project based learning (PBL) is a learning process based on the research, design, anything engaging students' minds-on activity and students' hands-on activity (Sumarni, 2013). In PBL there are challenging questions making students take the central role in design, problem-solving and decision making processes , giving them the opportunity to work relatively and autonomously (Sumarni, 2013). Additionally, PBL is significant in improving students' academic achievement, motivation, creativity/skills and attitudes (Sumarni, 2013). Zajkov and Mitrevski (2012) explains that PBL is a learner-centred approach, it does not condone students to memorize instead they are required to be more logical and critical in thinking as they analyse collected information to solve problems through project. In PBL, Thomas (2000) focuses on learning that involves students in investigation and problem solving, giving them a chance to work autonomously in building their own knowledge. Advantages of project based learning are as follows: increase students' academic achievement, cooperation/collaboration, students' creativity, problem-solving ability and students' attitude towards learning (Sumarni, 2013). Disadvantages of the project are that there are difficulties in implementing the method in large classes, during cooperative learning, in connecting new content with prior knowledge and in improving students' motivation (Blumenfeld, et al. 1991; Gulbahar & Tinmaz, 2006; Marx, et al. 1997.

2.7.9.4 Problem Solving

Aji and Budiyono (2018) state that problem solving is a technique that provides training and ability to solve problem from simple to complex. Problem solving is referred to as problem based learning strategy (PBLS) (Aji & Budiyono, 2018). When solving a problem there are five stages that need to be followed, for example, students' orientation to the problem, organising students to learn, guiding individual and group investigations, developing, presenting work, analysing and evaluating the problem solving process (Aji & Budiyono, 2018). Based on the present researcher's experience the steps mentioned above are very important and they promote skills that relate the new concepts with the environment. Furthermore, after solving the problem learners are able to report back in the form of presentations and assignments. The present researcher is of the view that, although the strategy is good it can also limit some learners; high performing students can dominate others especially the less gifted.

2.7.9.5 Case Study

Case studies are one of the top methods to use in the classroom, they help to interact in a meaningful way and problem solving skills are strengthened (Keller, 2016). Case study method is defined as an approach used to assist students to discover active solutions to challenges they encounter in relation to real life situations in a shorter time (Sunbul, 2010). Keller (2016) and Sunbul (2010) share the same understanding that case study permits active interaction to solve the problems encountered in real life situations. Therefore, the strategy allows for active engagement as it stimulates higher order thinking that drives students to participate actively to solve the problem.

The present researcher defines case study as the process of engaging students in deeper thinking about an issue, consulting relevant sources that will assist in finding the solution and then linking the information with the problem using logical thinking. Case study promotes advanced thinking and allows students to analyse a scenario or problem by following relevant stages and come to a conclusion. However, the strategy can be time consuming and affect the teaching and learning process.

2.7.9.6 Lecture

Lecture strategy refers to a chalk and talk method whereby the educator orally presents facts and ideas to learners (Achimugu, 2018). Anaekwe, Nzelum, Olisakwe and Okpala (2010) define lecture method as a process expressing orally a body of knowledge using the pre-planned scheme. The present researcher describes lecture strategy as a strategy whereby the educator is the only one talking , giving learners information expected to be learned from the course outline, while learners are listening and observing the whole process. It is the strategy that is not encouraged as the lecturer dominates in the learning process. However lecture strategy can promote the new concepts especially the complicated topics because the educator is imparting the new knowledge. Again it can be combined with problem solving to allow learners to receive information and at the same time pose questions to solve some of the issues in the new topic. Hence educators must not use it as a stand alone strategy. They must intergrate it with other strategies in order to use it effectively. Achimugu (2018) highlights that the weakness of the lecture strategy is that it does not encourage critical thinking; instead students are passive listeners throughout the lesson.

2.7.9.7 Discussion

Discussion Strategy is a way of managing the learning process, using problem solving skills and the educator engages students by giving them a task to argue about (Aji & Budiyono, 2018). The present researcher defines discussion as the strategy whereby the educator involves learners actively in the lesson by giving them concepts to unpack. Students use their analytical thinking, problem solving skills and research skills to debate and accomplish the expected outcomes. The strategy promotes co-operative learning and independent practice. The strategy also serves as a reinforcing strategy especially for exams. Literature highlights that educators need to engage students if they want their teaching to be successful (Aji & Budiyono, 2018). The present researcher concurs with Aji & Budiyono (2018), that if students are given topics to discuss, especially those in the course outline, it can sharpen their research skills. Chingombe (2013) states that learners are free to make some contributions during their learning processes and their views are respected. Gatawa (1990) emphasises that educators should ensure that group work is effective during discussion sessions.

2.7.9.8 Brainstorming

Alshammari (2015) highlights that brainstorming is regarded as an activity that can be used to introduce new concepts. While Al Mutairi (2015) states that it is a "technique that activates problem solving and captures student's interest'', the present researcher postulates that it is a strategy that invites students on board, attract their attention so that they concentrate on the new topic to be learned. It allows both senior secondary and higher education students to use their thinking and concentrate more on the topic to be presented. It also triggers the previous acquired knowledge so that it is linked with the the new knowledge especially when brainstorming using mindmap and diagrams. Ode (2014) mentions that brainstorming is advantageous for the reason that students are able to identify and come up with real questions to include in learning and involves critical thinking in the process. Students are able to come up with different ideas on how to solve a specific problem and devise strategies that best suit the process (Ikwumelu & Oyibe, 2014). Brainstorming is the best strategy which triggers creativity and solves problems in the education and other fields (AlMutairi, 2015). Students are able to learn from their and their peers' mistakes.'. Brainstorming serves as a cognitive procedure whereby a participant generates an idea and then stores it in the short-term memory (ALshammari, 2015). Yet, in overcrowded classes it can be ineffective.

2.7.9.9 Modelling

Abdullahi and Emmanuel (2014) define modelling as a strategy whereby the educator demonstrates a new concept or approach to learning and students learn by observing. Modelling is an effective instructional strategy and permits students to observe the educators' thought processes, and thereafter the educator engages students actively (Abdullahi & Emmanuel, 2014). It is one of the best methods of learning any new skill or knowledge (Bandura, 1986). The present researcher perceive modelling as significant for science learning since it is used as demonstration first and then after observe students applying the practical part. Modelling plays a key role in the acquisition and progress of cognitive and meta-cognitive skills, fine motor skills, interpersonal skills and later professional skill (Abdullahi, et al. 2014). Lack of both knowledge and relevant resources to be used may hinder the skill especially on the educators' side

2.7.9.10 Role-play

Role-play is a pedagogy used in various context and content areas (Hidayati & Pardijono, 2018). Akdeniz (2016) explains that in role-play students develop a role model and present the model in class. Students are able to take the role of another person and create deeper cognitive link to the material (Hidayati, et al. 2018). The present researcher defines role-playing as the process whereby students apply theory into practice, to demonstrate the skill that needs to be understood by students.

In addition, role-play has many benefits like effectively achieving learning outcomes. Akdeniz (2016) clarifies that roleplay is a brain based strategy under the affective domain. Therefore, it means the strategy uses brains because students have to apply thinking skills before acting the role. The present researcher agrees with Hidayati & Pardijono (2018) and Akdeniz (2016) however, the process needs students with confidence, good communication skills and are vocal. Shy students feel pressurised and intimidated, therefore learning can be inhibited. Hidayati et al. (2018) mentions the advantages of role-play as: (a) allowing students to practice new developed skills (b) increasing students' engagement (c) bringing real life experiences (e) and motivating students to learn. Akdeniz (2016) proposes activities that can be given to students for role-play purposes such as giving them a role model they are interested in and allowing them to present it. Let them dramatise the situation and link it to the lesson. Let them develop a process model for laboratory studies , then the educator can test the model to see if it serves the purpose.

2.7.9.11 Question and answer

Question and answer is a strategy that allows open discussion in terms of engaging students in a lesson, by posing questions linking both the prior knowledge and new knowledge. The benefits are: students are able to participate orally and good communication is promoted, interactive learning is also encouraged. Students are able to interrogate the educator when not satisfied with the feedback. Both discussion and presentation as well as brainstorming strategies are included in the strategy since questions are part of the strategy. Marzano (2003) defines the strategy as what the students already know to enrich what they are about to learn and also improves their ability to recover, use and organize what they already know about a topic. The strategy also encourages the asking of questions and gives students time for feedback (Marzano, 2003). Akdeniz (2016) also mentions that question and answer strategy encourages students to direct suitable questions to each other. Nevertheless, high performing students dominate cognitively challenged learners.

2.7.9.12 Presentation

Zivkovic (2014) states that presentation technique gives an opportunity for students to gain understanding into knowledge, at university level it equips students with communication skills and is a relevant segment. Girard and Trapp (2011) emphasize that in oral presentation, students gain knowledge not only from research but also from other presenters while presenting. In addition students are able to identify the strengths and weaknesses of presentations and they learn from others to improve their presentation skills. The present researcher defines presentation as a teaching strategy that trains students on good communication skills,planning skills, debating skills and increases confidence in public speaking. Oral presentation invites learners' attention and develops strategies on how to tackle the process. It also develops creativity. Presentation is the strategy that should be promoted at an early age, for example, from junior secondary school to senior secondary school to prepare learning for higher education. The strategy also adds value in the world of work. Girard and Trapp (2011) mentions the benefits of students' oral presentations as: (a) it encourages class interaction and contributions (b) improves interest in learning and (c) stimulates good communication and presentation skills. Therefore, it is used in all sectors when they want to be acknowledged, whether it is a business sector or education sector. It means presentation is currently the strategy that is still trending for the reason that it is significant to teaching and learning.

2.7.9.13 Investigation

Scientific investigation is an all-inclusive approach to learning science through practical work (Woolnough, 1991). The aim of science investigation is "to offer students opportunities to use concepts and cognitive processes and skills to solve problems" (Got & Duggan, 1996: 26). Educators' knowledge of science investigation is essential to their teaching of it (Anderson, 2002). Students benefit the most from the strategy. For instance they are able to discuss expectations, do observations, conclusions, theories and explanations before, during and after conducting the activity (Patrick & Yoon, 2004). Investigative strategy consists of four phases: a design and planning phase, a performance phase, a reflection phase and a recording and reporting phase (Hodson, 2009). CAPS DBE (2011) mentions cognitive and practical process skills in natural sciences which are: Accessing and recalling information, Observing, Comparing, Measuring, Sorting and classifying, Identifying problems and issues, Raising questions, Predicting, Hypothesizing, Planning investigations, Doing investigations, Recording information, Interpreting information and Communicating.

2.8 Educator support for science learning and promoting SL

The concept support means to agree with and give reinforcement to someone or something for the reason that you want something to be successful. Educator support is explained as mentoring, coaching, professional development and feedback upon lesson observations (Nkambule & Amsterdam, 2018). The poor academic achievement of school learners has forced the government to take a number of further steps to advance the quality of schooling in South Africa (Phasha, Bipath & Beckmann, 2016). Mestry, Hendricks and Bisschoff (2009) argue that improving the quality of educators has a positive influence on learners' achievement and the overall performance results in the education system. In addition, the same authors further mention that improving quality of educators can be done through professional development. In concurring with the authors above Kriek and Grayson (2009) propose that educators need professional development on content knowledge, teaching approaches and professional attitudes. Boardman and Woodruff (2004) observe that not many educators have been trained to manage and implement the practices related to these strategies. Furthermore, educators can be supported by giving them advice concerning planning and professional activities that focus on the implementation of active learning or cognitive activation. Therefore, after improving the quality of educators through professional development and trainings, follow up from district officials (subject education specialist) are needed to see if the educators are implementing the curriculum in the way it is supposed to be done. However, Taole (2013:44) mentions that the "trainers need to be properly trained to avoid misinformation and misinterpretation of the policy documents by educators".

Phasha, et al. (2016) highlight that the quality of education can be improved only if educators' challenges are positively addressed with respect to lack of resources, support, regular feedback from the authorities and challenges faced especially by rural schools, which hinder effective curriculum implementation. Taole (2013) mentions that monitoring and support go together to ensure that the curriculum is implemented effectively and the people responsible for that include Senior Management Team (SMT) and curriculum advisors. During the monitoring and implementation of a new curriculum, educators should be given opportunities to voice out their concerns about the curriculum. Thus, Phasha, et al. (2016) state that monitoring is the key to control the deficiencies and challenges that educators encounter and optimise their successes. The present reseacher concurs with the authors referred to above by highlighting that support through monitoring and team work with both curriculum advisors and school management team can assist educators to boost quality teaching and learner performance.

Bantwini (2009) points out that, in some cases, educators are just given the policy documents to study and are expected to apply the information in the classroom. This leads to incorrect implementation of the curriculum by the educators. Hence, the importance of support is emphasized above. If support is not active, misunderstanding of the curriculum can limit the quality of education. Literature illustrates that lack of support from the district personnel has been coupled with a lack of school subject area committees to guarantee that educators assist each other with challenges encountered (Bantwini, 2009). Duties of curriculum advisors are not well-coordinated between district office and circuits and also at the provincial level (Brynard & Netshikhophani, 2011).

It is also important for curriculum advisors to identify the type of support needed per school. Sometimes educators lack content knowledge which is very serious and can hinder the achievement of the curriculum objectives. Curriculum advisors can experience challenges in offering educators support where they themselves have inadequate knowledge of the subject matter (Phasha et al. 2016) and support cannot be effective if educators are teaching subjects for which they were not trained. In supporting the statement above, the present reseacher feels that teaching a subject in which an educator is not a specialist is a serious challenge that can affect the students' progress and disadvantage the quality of science learning. Phasha, et al (2016) suggest that in professional development, educators develop their pedagogic content knowledge, which could be outside their subject specialization.

In addition, a critical subject like science needs someone who is a specialist and understands all the strands mentioned in the CAPS document. Now educators who teach in schools must be supported by experienced educators, educational researchers, advisors and inspectors (Ellis 2007). Bantwini and Diko (2011) emphasize that most schools cannot afford to purchase science equipment to support effective teaching and learning at schools. Therefore, it is a challenge that needs urgent attention from DOE. It is apparent that without relevant science material for practical work science cannot be taught effectively.

Concerning ICT strategy, out of South Africa's 413067 educators, only 132 884 had been trained in basic computer skills and ICT equipment by 2011 (Ngubeni 2014). This means that the educators need support in terms of applying strategies in the classroom. Literature reveals that some educators were receiving different types of support while others had to rely on school only for support (Ngubeni 2014). The support structures mostly offered in the rural South African districts are: Educators assisting each other, Cluster support, District office official, Province DBE official, and Non Governmental Organisations (NGOs).

While educators work together to reach the common goal of enhancing the teaching and learning of a certain subject, they also boost the content knowledge of those educators with challenges in a subject matter. New educators benefit when discussing the complicated science strands, especially in groups. Regarding cluster support, authors have different views on how educators are supported to enhance the teaching and learning of science. A project called Mpumalanga Secondary Science Initiative (MSSI) conducted a study in one of the senior secondary schools in the Mpumalanga Province of South Africa on educators working as clusters. It observed the use of the normal cascade approach, where subject advisors trained the Heads of Department who then trained the classroom educators (Jita & Mokhele, 2014). These authors note that clusters enhance educator's content knowledge and pedagogical content knowledge. Again the authors above mentioned that educators identified the benefits of clusters as promoting collaboration, instructional guidance and educator leadership.

Furthermore, they highlighted the advantages of working as clusters whereby educators participate in other educator's classroom practices more directly, do common planning like setting common assessment tasks and carry out team-teaching in different schools.

Lastly, the subject advisor serves common pace setters to ensure that all educators teach the same content as per the CAPS policy. The present researcher is of the view that these pace setters will enable learners who move from one school to another to catch up easily. Jita and Mokhele (2014) argue that there is no verdict yet about cluster effectiveness. Therefore, the present researcher's opinion is that educators' success of working in clusters depends on the support given by the Department of Education curriculum specialist. Findings of the MSSI project were that educators' collaboration with colleagues was successful as it provided opportunities for the MSSI educators to improve their pedagogies. They were able to do integration of subject matter within and across disciplines. Jita and Mokhele (2014) aver that there is evidence of participating educators assisting those educators with content gap in the subject matter. Moreover, they wonder how it is possible for educator leaders to organize and facilitate the instructional guidance of their colleagues with such proficiency (Jita & Mokhele, 2014). The present researcher's view is that commitment, dedication and love of the subject push educators to walk the extra mile to support each other. Positive support from the district officials enhance cluster meetings.

DBE district officials provide support to educators in different ways. When educators get support, they are able to improve their teaching techniques and become knowledgeable about the content. To effectively teach science educators must not only master science content, but also be familiar with how learners learn science (Adamson, Santau & Lee, 2013). Adamson et al. (2013) further mention that engaging educators more in the learning process can make a difference and it can also be a part of on-going professional development. Therefore, the present researcher opines that for educators to master the content they need to develop themselves and also avail support from DBE and other stakeholders to work hand-in-hand with DoE.

In South Africa, DBE and the Department of Science and Technology (DST) prioritise academic performance and skills in mathematics and science (Mbowane, Devilliers & Braun 2017). DST supports science through Eskom Expo for young scientists and promotes science for fair events. Science fair events are projects that are educational and they contribute to pedagogical content knowledge (Mbowane, et al. 2017). Mbowane, et al. (2017) also highlight that learners improve in both science and maths through science fair events. With regard to the above science events, the educators have significant roles to play such as mentoring, organising, collaborating, networking and judging (Mbowane, et al. 2017). The same authors further mention that the educators observe that science fairs enhance the skills, attitudes and knowledge of learners and encourage future careers in SL oriented professions. The educators in their sample further mentioned that the science fairs challenge learners with academic rigour, establish useful skills and complement other efforts to address the science achievement gap.

The present researcher who is an experienced science educator agrees with the authors that these science events really promote networking amongst educators. They are able to share information with other provinces and other countries. For instance we attended a conference organised by DBE for science, technology and mathematics with educators across the borders. They were here in South Africa, Eastern Cape to share their expertise in the three disciplines already mentioned. We showcased our strategies and content knowledge and it was successful. Nkambule and Amsterdam (2018) emphasize that educator support is a vital ingredient in the working of education systems across the world and novice educators require support as they try to find their feet in the profession, make sense of reform initiatives and implement policy.

Literature suggests that education districts and circuit offices are required to conduct "school visits, classroom observation, consultation, cluster meetings, suitable feedback reports and other means; providing an enabling environment and organising provision and support for the professional development of managers, educators and administrative staff members; and holding education institutions in a district area to account for their performance" (National Education Evaluation & Development Unit, 2013:15). The Foundations For Learning (FFL) Campaign (DoE, 2008:22) stipulates that "education district officials are obliged to visit all schools within the district at least once per term, with more frequent visits to schools requiring stronger support for monitoring and guidance, assist schools to improve their performance and work towards the agreed targets".

The literature shows that countries such as Finland, Australia, Japan and the United States made significant investments in educator training, educator induction, educator development and professional development with considerable emphasis on collaboration among schools (Abbott, Middlewood & Robinson, 2014; Australian Institute for Teaching & School Leadership, 2012; Li & Zhang, 2015 and Moore, 2016). Eastern Cape Department of Education (ECDoE, 2015) confirms that for the next five years, the Department will carry on responding to the challenges of the province concentrating mostly on improving the quality of education, learning processes and outcomes in its education programme.

There is a programme called Globe in South Africa under the Department of Science and Technology's Youth into Science Strategy which aims at promoting science learning and SL among the youth and nurturing young people's talent for science engineering and technology related careers (SAASTA, 2016). The aim of the programme is to support educators to teach science effectively and prepare learners for the world of work. SAASTA (2016) also mentions the support given to educators in a rural district in Eastern Cape Province, South Africa.

In addition, the educators were given a mobile laboratory in 2014. The mobile laboratory was jointly funded by DST, SAASTA and Sasol Inzalo Foundation. The mobile laboratory was equipped with science apparatus and chemicals to allow educators and learners to conduct experiments. The main purpose of the project was to improve learners' performance in science and to empower educators (SAASTA 2016).

Non-governmental bodies (NGOs) play a role in some of the schools in the South African district by giving support in science teaching. Gosa (2018) highlights that one of the NGO programme is Technology Research Activity Centre (TRAC SA). Its purpose is to assist science, mathematics and technology education in schools. Gosa (2018) quotes a TRAC official mentioning an agreement between Eskom and TRAC SA towards supporting science education. Eskom invests in communities where there is Eskom infra-structure and assists government by providing support in improving access to quality education. Gosa (2018) further mentions that TRAC SA has stimulated interest through exciting methods in the teaching and learning of science. Eskom's aim is to increase the intake into science and engineering for future skills' needs, at the same time focus on improving the pass rate. TRAC SA is implemented in 30 selected schools in five districts in the Eastern Cape Province. It is meant for grade 10 to 12 learners, however grade 9 learners also benefit since in most schools the educators attending the workshops teach grade 9 learners too. Gosa (2018) further explains that the programme has shown good results so far, both educators and learners are benefiting and learners are exposed to hands-on activities.

Another programme is National Education Collaboration Trust (NECT) which supports educators in Eastern Cape in different subjects including science. ECDoE embarked on a 2018 Educator Development Programme in collaboration with the NECT for educators of Grades 1-9 in four key subjects i.e. Home Language, English First Additional Language, Mathematics and Natural Science (Curriculum Instruction G03/2017). The curriculum instruction also notes that ECDOE-NECT programme provides practice-based support for educators to improve the quality of teaching and learning in the above-mentioned subjects and the initiative is to support educators to complete the curriculum at the correct pace and grade level using a tracker (Curriculum Instruction G03/2017). A tracker consists of CAPS concepts and activities, weeks with lesson A or B included, topics from CAPS policy document with page numbers and a date to complete the lesson.

The NECT was launched in 2017. It may take two years to find roots. According to Curriculum Instruction G03/2017, full implementation of the ECDOE-NECT toolkit (Planners, Trackers, Lesson Plans and Content Modules) in natural science and mathematics will take place in the Intermediate and Senior Phases in 2019. DBE (2018) mentions that teaching awards are used to motivate and support educators and focus on identifying and promoting excellence in teaching performance. In addition, NECT encourages best practice in schools and honour dedicated, creative and effective educators and schools.

2.9 Classifications of strategies

Akdeniz (2016) observes that there can be several headings under which instructional strategies can be classified. There are variables that play a role in doing these classifications e.g. what the focus of instructional activities is, what methods and techniques are used in the process; whether the process is followed with an inferential, deductive or inductive understanding; and which constructs are taken into consideration in the preparation, presentation and restructuring of the information. Moreover, the report mentions that the instructional strategies are also classified in other studies as to how the process functions, how information is produced and how information is acquired by learners. Subsequently, learning and teaching approaches, theories and models have influence on the formation of strategy groups to categorize strategies.

Table 2-1: The classification of instructional strategies

Author	Classification								
Saskatchewan Education (1985,1991)	Direct instruction	Interactive instruction	Independent/individual study	Experiential instruction	Indirect instruction				
Merrill(1987)	Regulation strategies	Message strategies	Orientation strategies						
Sedgwik (1999)	Give up/ discourage	Warn/alerted	To be informed/to inform	Volunteer/ make voluntary	Win/bring				
Marzano, (2001)	Identifying similarities and differences	Summarising and note taking	Reinforcing effort and providing recognition	Homework and practice	Non-linguistic representation such as mental, images, graphs, acting out content	Cooperative learning	Setting objectives and providing feedback	Generating and testing hypothesis	Activating prior knowledge via question, cues, advance organisers
O'Brien (2005)	Effective instructional strategies	Educator orientated strategies	Student oriented strategies						
Ray (2005)	**Web-based strategies**								
	Encouragement of student-centered instruction	Encouragement of student collaboration	Encouragement of effective learning	Giving prompt feedbacks	Emphasizing on time duties	Create high expectations	Supporting implicit learning		
Huang (2006)	**Brain-based strategies**								
	Cognitive domain group	Affective domain groups	Physico-motor domain group						

<table>
<tr><td></td><td>Whole brain str.</td><td colspan="3">Left brain str.</td><td>Right brain str.</td><td>Metacognitive str.</td><td colspan="3">Security and trust str.</td><td colspan="2">Attention str.</td><td colspan="2">Social interaction str.</td><td colspan="3">Physical environment str.</td></tr>
<tr><td>Killen (2007)</td><td>Direct instruction str.</td><td colspan="3">Discussion str.</td><td>Small group discussion str.</td><td>Cooperative instruction str.</td><td colspan="3">Problem solving str.</td><td colspan="2">Inquiry str.</td><td colspan="2">Role-playing str.</td><td colspan="2">Case studies</td><td>Writing str.</td></tr>
<tr><td>Bazan (2007)</td><td colspan="5">Student directed str.</td><td colspan="6">Educator directed str.</td><td colspan="5">Without instruction design str.</td></tr>
<tr><td rowspan="2">Edvantia (2005)</td><td colspan="7">Macro strategies</td><td colspan="9">Micro strategies</td></tr>
<tr><td colspan="3">Metacognition</td><td colspan="4">Active student engagement</td><td colspan="4">Higher order thinking</td><td colspan="2">Cooperative learning</td><td colspan="3">Independent practice/homework</td></tr>
<tr><td rowspan="2">Eri sti & Akdeniz (2012)</td><td colspan="3">Focus strategies</td><td colspan="13">Process strategies</td></tr>
<tr><td colspan="2">Instructor oriented str.</td><td>Learners oriented str.</td><td colspan="2">Problem solving case studies str.</td><td>Discussion brainstorming str.</td><td colspan="2">Modelling, simulation, role-playing str.</td><td colspan="2">Thinking, criticise, comment str.</td><td colspan="2">Presentation on str.</td><td colspan="2">Question-answer str.</td><td>Writing, summarising, taking notes str.</td><td>Project, investigation str.</td></tr>
</table>

Adapted from Saskatchewan Education (1985, 1991), Edvantia (2005), Sedgwik (1999), Marzano (2003), Killen (2007), Bazan (2007), Erişti and Akdeniz (2012)

Table 2.1 shows that science inquiry belongs to all the domains in the teaching. For instance in cognitive domain: direct instruction, discussions and co-operative instruction are involved in science inquiry based learning and it promotes learner-centred approach. Again the affective domain and psycho-motor domain involve role-play and case study whereby learners use critical thinking on scenarios displayed by the case studies. All these domains are brain based strategies i.e. they require learners to focus and pay attention in the classroom.

Moreover, the strategies are divided into focus strategies and process strategies that will assist the educators when implementing science in the classroom. The present researcher believes that to enhance science learning and promote SL, it is important for educators to understand the diagram and be able to link the strategies in order to achieve the outcomes of the lesson. Both ICT and POE strategies are also linked in the diagram. In the light of Table 2.1 the educators will have to understand what to do when using certain strategies, for example, micro strategies. Educators will be able to know what to expect if they formulate objectives that will achieve critical thinking or enhance demonstration skills.

Saskatchewan Education SEd (1985, 1991) reports explain that instructional strategies refer to individual and specialized fields. These instructional strategies are referred to as direct instruction, indirect instruction, interactive instruction, independent study and experiential instruction (Saskatchewan Education, 1991). These reports elaborate that direct instruction strategy is effective for providing information or developing step-by-step skills. The strategy is good as it can involve other teaching or actively involve students in knowledge construction.

In addition, the Saskatchewan Education (1991) report states that indirect instruction is student-centered and examples include reflective discussion, concept formation, concept attainment, cloze procedure, problem-solving and guided inquiry. The report mentions the advantages of interactive indirect instruction as one to strive for a high level of student participation in forming hypotheses, investigating, observing, and drawing inferences from data. It takes advantage of students' interest and curiosity, often encouraging them to make other choices to solve difficulties. Interactive instruction relies profoundly on discussion and sharing among participants and allows for a range of groupings and interactive methods.

2.10 Strategies relevant in enhancing science learning and promoting SL

These strategies are relevant in promoting science learning and SL because they align more with CAPS. They are learner-centred and engage the student actively in constructivist classrooms. Wang and Wen (2010) note that in the inquiry-based approach, learners benefit by gaining better understanding of the content and are able to think critically and creatively. Akdeniz (2016) highlights that in some new taxonomies, instructional strategies are connected with brain-based learning rules. Another taxonomy connects the strategies in five groups: strategies for experiment, indirect instruction, direct instruction, interactive instruction and independent study/individual instruction. Science inquiry, ICT and POE involve experiments and indirect instruction whereby learners are given a task e.g. a topic and then they decide themselves which approach they will use and resources that will link with the task. In direct instruction they are given a case study or project to do with instructions to follow. In interactive instruction, learners participate in the class where both the educator and learners work together. Independent study expects learners to work on their own, especially during assessment.

2.11 Science inquiry

The term inquiry generally signifies the process of acquiring or obtaining information by investigation, often personally and voluntarily carried out by the person who is eager to know the phenomenon in question (Shamsudin, Abdullah and Yaamat, 2012). Hiang (2005) explains inquiry as the process that includes investigation of a problem; finding truth or knowledge that requires critical thinking, making observations, asking questions, thinking creatively and using intuition, doing experiments and stating conclusion. In addition, inquiry is a process of understanding the characteristics of science through SL experiments and through try-outs ant testing. Science inquiry promotes constructivist approach in that it involves learners more in the teaching and learning of science. It also enhances learner's critical thinking. The comparison and contrast is shown below (Franklin, 2002).

Table 2-2: Comparison between inquiry-based and traditional teaching methods

Characteristics	Inquiry- based	Traditional
Principle Learning Theory	Constructivism	Behaviourism
Student Participation	Active	Passive
Student Involvement in Outcomes	Increased Responsibility	Decreased Responsibility
Student Role	Problem solver	Direction follower
Curriculum Goals	Process oriented	Product oriented
Educators' Role	Guide/facilitator	Educators' Role Guide/facilitator Director/ Transmitter

The Table 2.2 shows the importance of science inquiry strategy in promoting science learning and SL. The strategy engages learners more in the lesson and learners develop problem solving skills and become responsible for their actions. However, the traditional method promotes memorization and the educator is seen as the transmitter of knowledge.

The primary National Curriculum by the Departent for Education, DfE in England (DfE, 2014) indicates that the nature, processes and methods of science, which require the application of inquiry skills, need to be developed within varying contexts of science across the disciplines of biology, chemistry and physics. The three subjects integrate with each other and so educators need to apply inquiry skills to enhance the teaching and learning of science. Under science inquiry strategy there are five inquiry based methods which are used in the teaching and learning of science.They are: Simulation, Experiment, Demonstration, Project work and Field work.

2.11.1 Simulation

Perry et al.(2009) define simulation as a form of experiential learning, an instructional strategy where the learner is placed in a world made by the educator. Perry et al. (2009) further mention that through games, role-play and model, the learners get actively involved in the learning, especially in the lab where they do experiments.

2.11.2 Experiment

Experiment deals with practical work in science, and it promotes hands-on learning experience that prompts thinking about the world in which we live in. Experiment is the core of doing investigation in science classroom (Nurshamshida, Nabilah & Nurlatifah, 2013). Furthermore, educators carry out experiments to motivate learners and arouse their interest in science learning (Nurshamshida, Nabilah & Nurlatifah, 2013). Experiment is a good strategy for science teaching as it engages learners actively in the lesson.

Denscombe (2010) explains an experiment as an empirical investigation under controlled conditions designed to examine the properties of, and relationship between, specific factors. The above author further elaborates that the idea of an experiment tends to be linked with white-coated scientists working in a laboratory possibly using highly sophisticated equipment to measure things with extreme precision. Denscombe (2010) also mentions that the purpose of the experiment is to discover new relationships or properties associated with the materials being investigated, or to test existing theories.

DfE (2014) states the importance of investigation when doing practical work. For instance, learners need to be equipped with SL knowledge and skills to understand the uses and implications of science today and for the future. The types of investigations prescribed are: observing over time; pattern seeking; identifying, classifying and grouping; comparative and fair testing (controlled investigations) and researching using secondary sources. It is suggested that SL learners should be equipped with science inquiry skills and science methods (DfE, 2014). The scientific inquiry skills suggested are as follows:

- asking relevant questions and using different types of SL enquiries to answer them;
- making systematic and careful observations and, where appropriate taking accurate measurements using a range of equipment;
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions;

- recording findings using simple language, drawings and labelled diagrams;
- reporting on findings from enquiries, including oral and written explanations or presentations of results and conclusions;
- using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions and
- using logical SL evidence to answer questions or to support findings.

The above-mentioned skills are also emphasized in NS CAPS document in the specific aims (DBE, 2011). Harlen (2014) also mentions the above skills by highlighting that science inquiry extends beyond just practical work and that it is concerned with the development of a range of skills. Ofsted (2016) argues that these types of skills can be limited due to educators’ lack of expertise. Therefore, the educators’ content knowledge as well as pedagogical content knowledge are important in order to be an expert in the discipline and be able to transfer the knowledge effectively. This is also avered by Shulman (1986) who views that an expert educator is able to teach effectively if the teacher has knowledge and understanding of it. Magnusson, Borko and Krajcik (1999) concur by stating that pedagogical content knowledge reflects an educator’s understanding of how to help learners undesrtand a specific topic and subject. The Royal Society (2010: 66) also is concerned with the way in which children are prepared for scientific literacy for future, adding that understanding science involves much more than just the learning of facts. For instance, the development of SL and research skills in science education are considered important and they are to serve two important key objectives, that is, to improve science learning and SL and to stretch and challenge those with the potential to become tomorrow’s scientists (Royal Society, 2010). In addition, the Confederation of British Industry (CBI, 2015) in their report emphasises how learning science must be addressed at the primary phase of education if schools are to nurture science literate citizens for the future. Furthermore, Ofsted (2013: 10) notes that youngsters “learn best when they could see how the science they were studying is linked to real world experiences”. Therefore, in order to promote science learning and SL, different skills need to be considered, including science inquiry skills.

2.11.3 Demonstration

McFarland (2005) explains that demonstration is very helpful in promoting learning by proving the existence or the truth of something through evidence. Demonstrations of surface tension using varying objects, and of solubility and solutions using salt and canned drink can help capture students' attention in class (Nurshamshida, Nabilah & Nurlatifah, 2013).

2.11.4 Field work

Field work in an academic or other investigative studies is undertaken in a natural setting, rather than in laboratories, classrooms or other structured environments (Noel, 2007). In addition, activities done in an external environment promotes aspects of discovery, open discussions and give the freedom to choose information deemed as most beneficial (Noel, 2007).

2.11.5 Project work

Ojo (2007) explains that project work is a strategy that allows for more meaningful understanding of science concepts amongst learners and enhances their academic performance**.** Project work also helps educators in the development of their science content knowledge (CK) as well as their science pedagogical content knowledge (PCK) as they prepare and facilitate learners' work (Ojo, 2007).

2.12 Use of Information and Communication Technology (ICT)

Information and Communication Technology (ICT) is defined as a diverse set of technological tools and resources used to create, communicate, disseminate and manage information (Digital Strategy for Schools, 2013). Ibe-Basse (2011) defines ICT as a critical tool for preparing and educating learners with the required skills for the global work place. The difference between the two definitions is that in the former one the aim is communication using technological tools while in the latter, the aim is preparing learners for the world of work. This implies that when learners are able to use technology gadgets in class they will be able to use them successfully at work.

ICT plays a significant role in schools. Butler et al. (2013: 8) explain that ICTs “support an enquiry process and enable the learners to work on solving complex real world problems by engaging in collaborative project-based learning activities that go beyond classroom”. The present researcher concurs that the use of ICT in curriculum implementation promotes constructive approach in the class. Research studies of Butler, et al. (2014) and OECD (2015) indicate that an educators’ pedagogical orientation is a key factor in the use of digital technology in the classroom. They mention that effective use of digital technology is associated with constructive approaches to teaching, for example, considering learners’ prior understanding and active involvement of learners in the classroom.

The programme formulated by the Irish government and stakeholders termed Digital Strategy for Schools 2015-2020 state that there are key principles that inform the digital strategy for schools. The principles are displayed in the table 2.4 below. Since the principles link with constructivist approach, the educators will learn more in terms of using ICT for both teaching and assessment.

Table 2-3: Key principles informing the digital strategy for schools

Principle	Descriptor
A Constructivist Pedagogical Orientation underpinning the embedding of ICT in schools.	A constructivist pedagogical orientation supports educators in effectively using ICT with their learners i.e. learners are actively involved in a process of determining meaning and knowledge for themselves.
The use of ICT in teaching, learning and assessment can enhance the learning experiences of all learners.	ICT plays an important role in supporting inclusion and diversity for all learners by enhancing learning opportunities for all learners.
The use of ICT in teaching, learning and assessment is embedded in school curricula, Department policies and educator education.	The Department and its agencies will play a proactive role in implementing the Digital Strategy for Schools.
CT is used in an ethical and responsible way.	Schools and the Department enable all users to use ICT in an ethical and safe way.
CT Planning is required to ensure ICT integration in teaching, learning and Assessment.	All levels of the education system are engaged in inclusive planning for the effective integration of ICT.

Taken from: Digital Strategy for Schools (2013)-Enhancing Teaching, Learning and Assessment

There is a growing evidence that "digital technologies change the way learners learn, the way educators teach, where and when learning takes place" (21st Century Learning Reference Group, 2014: 4). Thus, learners need more "open-ended learning that develop learners' higher-order thinking, creativity, independency, collaborating and ownership of learning" (Department of Education and Skills, 2013: 20). ICT integration is very important to enhance micro strategies that develop critical thinking in learners. However, if there is lack of knowledge on the educators' part, ICT learning process can be inhibited. Digital Strategy for Schools (2013) explains that in order to use ICT effectively in the classroom, educators need to have a sound knowledge of ICT. Koehler and Mishra (2009) refer to a framework known as Technological Pedagogical and Content Knowledge (TPACK). Its purpose is to describe the levels of knowledge which an educator requires in order to be able to integrate ICT in their practices. For effective pedagogical practice, the three types of knowledge required by an educator are (a) a mix of technological knowledge (TK), so that they can use ICT successfully; (b) a deep knowledge of the curriculum content (CK) and (c) pedagogical content knowledge (PCK) in order to teach the subject content area successfully.

2.13 Predict-Observe-Explain Strategy

This strategy aligns with the specific aim1 of CAPS natural science sylllabus already mentioned. In addition, the strategy deals more with practical tasks, whereby learners are expected to predict first before observing, then come up with findings and explain them. This is a process using constructivism and learners are actively involved. In the laboratory, learners sometimes work in groups when doing experiments and they become motivated. The strategy puts the learner as the active participant and the educator as the facilitator. The strategy was first developed by White and Gunstone (1992) and the aim was to emphasize the importance of predictions in science subjects.

The Department of Basic Education (2011c) states clearly that in learning Natural Sciences, learners should be assisted to develop important cognitive and practical process skills.

According to Assessment Resource Banks (2007) POE strategy works as follows:

- Learners must predict what will happen before they observe;
- having their prediction motivates them to find the correct answers;
- learners get to explain reasons behind their predictions that assist the educator to understand learners' theories. This can also be useful to uncover learners' misconceptions;
- provides information for making decisions about the subsequent learning;
- learners get the opportunity to discuss and evaluate predictions, listen to others' predictions and to begin evaluating their own learning to construct new meanings.

2.14 Assessment on science learning and promoting SL

The purpose of assessment is to measure the extent to which the desired knowledge, skills and attitudes are attained by learners, while it complements the teaching and learning process. In Pisa 2006 on assessment, it is explained that, assessment is an integral part of the teaching and learning process (Rodger, Barry, & Robert, 2009). It involves gathering information through various assessment techniques and making sound decisions. In addition, assessment provides the educator with the information about learners' achievement in relation to the learning objectives. It also provides formative and summative feedback to learners, educators, schools and parents (Rodger, Barry, & Robert, 2009). After learners receive feedback, they will be able to identify their weaknesses. Then, educators can do reflection on the strategies used to deliver the content. If there is a high failure rate, then they will change the method and revise the content again. Furthermore, positive feedback boosts the educator's confidence and simultaneously enhances teaching and learning.

Other researchers voice out that assessment is an integral part of learning and is seen as a key component in quality teaching, essential for raising students' achievement by supporting learning (Absolum et al. 2009; Black William, 1998a, 1998b &; Crooks, 1998; Ministry of Education, 2007, 2011; Stiggins, Arter, Chappuis & Chappuis, 2004). Edwards (2013) clarifies the importance of assessment and also emphasizes that science educators must use high quality assessment process when assessing learners.

Park and Olivier (2007) aver that knowledge of assessment of science learning is seen as an important component of PCK. The component involves knowledge of the important dimensions of science learning to evaluate assessment methods and specific assessment approaches and activities (Park & Olivier, 2007; Tamir, 1988). Quality assessment is very important in science, it has to meet the requirements of the specific learners whose learning is being assessed (Edwards, 2013). Rundle (2016) postulates that assessment is designed to promote student learning and measures student accomplishment against learning outcomes to produce grades that are valid, consistent and sustain academic standards.

When designing assessment, ensure that it is authentic, fair and equitable. Integrity is to be maintained by minimising plagiarism, using various assessment methods and moderating of assessment (Rundle, 2016). Furthermore, (Rundle, 2016) explains that moderation is important to ensure integrity in the assessment following the process of validity and reliability. Therefore, educators are required to develop the skills that will assist them in designing assessment tasks that will also value prior learning and learners' abilities (Edwards, 2013).

Brookhart, 2011 renewed a list of eleven competencies in educational assessment knowledge and skills for educators. According to Brookhart (2011) some of these competencies are as follows:

- Educators should understand the content in the area they teach.
- Educators should be able to articulate clear learning intentions that are congruent with both the content and depth of thinking implied by standards and curriculum goals, in such a way that they are attainable and assessable.
- Educators should have a collection of strategies for communicating to learners what achievement of a learning intention looks like.
- Educators should have the skills to analyse classroom questions, test items and performance assessment tasks to discover the specific knowledge and thinking skills required for learners to do them e.g. using cognitive domains.
- Educators should have the skills to provide effective, useful feedback on student work.

In an inquiry-based classroom, the assessment can take many forms. Besides written tests, educators can also conduct performance-based assessment using activities such as practicals, projects, games, quizzes, debates and drama (Rodger. Barry, & Robert, 2009). Educators can also assess learners through the use of portfolios. It involves a systematic collection of learners' work and provides a comprehensive picture of their achievement (PISA, 2006). Moreover, the work collected provides a continuous record of the learners' development and progress in the acquisition of knowledge, understanding of SL concepts, application of process skills and development of attitudes (PISA, 2006).

2.14.1 Assessing using higher order thinking

When assessing it is important for educators to use higher order questions to cater for all levels of learning. Brookhart (2011) identifies definitions of higher-order thinking as falling into three categories; those that define higher-order thinking in terms of transfer, of critical thinking and of problem solving.

2.14.1.1 Higher order thinking in terms of "Transfer"

Brookhart (2011) explains that when learners acquire knowledge, they must be able to apply it to new situations outside the school. For instance, the student can link what happens at school with what is happening in the community, like learning about purification of water at school then applying the knowledge at home indicating knowledge transfer. This is all about learning science and promoting SL.

2.14.1.2 Higher order thinking in terms of critical thinking

Critical thinking refers to learners' ability to apply wise judgement or produce a reasoned critique (Brookhart, 2011). In addition, the goal of teaching is to equip learners by guiding them towards how to exercise reasoned judgement and make sound decisions. The skills learners need to be taught to do this include the ability to judge the credibility of a source and identify assumptions. When learners develop critical thinking, they are able to make decisions on their own in terms of choosing the best career and are also able to critique issues concerning their teaching and learning. In addition, learners are able to be involved in debates. Involvement in debates occurs mostly when they work in buzz groups where they are expected to give feedback about topics given for discussions. Critical thinking is also promoted by constructivist approach.

2.14.1.3 Higher order thinking in terms of problem solving

Brookhart (2011) argues that if educators think of higher-order thinking as problem solving they can set lesson goals to teach learners how to identify and solve problems at school and in life. The skill will assist learners to develop independency when tackling problems. Blooms taxonomy (1956) came with the frame work that emphasizes higher order thinking and the aim was to promote higher order thinking in education, such as analysing and evaluating, rather than just teaching learners to remember facts (rote learning). Bloom (1956) states that learning is divided into three domains:

- Cognitive: mental skills (*Knowledge*)
- Affective: growth in feelings or emotional areas (*Attitude or self*)
- Psychomotor: manual or physical skills (*Skills*)

The cognitive domain involves 'knowledge and the development of intellectual skills' (Bloom, 1956). In addition, the abilities and skills within the domain are listed in six major categories starting from the simplest thinking behaviour to the most complex. Table 2.4 below equips educators with skills when they are planning their lessons and assessment. Table 2.4 is revised by Anderson (2000), along with colleagues who revisited the cognitive domain in the taxonomy and made two major changes. Anderson (2000) changed the six categories from nouns to verbs and slightly rearranged them.

Table 2-4: Bloom (1956), Anderson and Krathwohl's Taxonomy (2001)

Bloom	Anderson
Knowledge	Remembering Examples: Using memory to produce definition, facts, lists, recite or retrieve materials. Key words: Retrieve, Recall
Comprehension	Understanding Examples: Constructing meaning from different types of functions. Key words: Interpreting, exemplifying, classifying, summarising, compare and explain
Application	Applying Examples: Applying related information, skills and referring to situation where learning material is used through products like presentations, interviews or simulations. Key words: Executing, implementing
Analysis	Analysing Examples: Breaking material or concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose. Creating surveys, charts, diagrams or graphic representations. Key words: Differentiating, organising, attributing as well as being able to distinguish between the components or parts can represent analysis.
Synthesis	Evaluating Examples: Critique, recommend, report are some of the products that can be created to demonstrate the process of evaluation. Key words: Checking, critiquing
Evaluation	Creating, Examples: Creating requires to put together in a way or synthesise parts into something new and different to form a coherent or functional whole. Key words: Reorganising, generating, planning, producing

Table 2.4 shows how Bloom (1956), Anderson and Krathwohl (2001) categorised knowledge acquisition. Bloom (1956) also highlighted that planning classroom questions is very important. In addition, discussions in class can be disrupted if they are not well planned with higher order thinking learning objective in mind. Furthermore, educators should encourage learners to reflect on their learning so that they understand their thinking strengths and weaknesses.

Affective domain is one of three domains in Blooms' Taxonomy, with the other two being the cognitive and psychomotor (Bloom et al. 1956). According to Krathwohl, Bloom and Masia, (1973) affective domain includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations and attitudes. Grauer (2014) also confirms that the affective domain includes emotions, feelings, values and acceptance or rejection of a topic. Krathwohl's Taxonomy of the Affective Domain provides a classification system for developing affective educational objectives (Krathwohl, Bloom, & Masia, 1964). Affective Taxonomy behaviour is classified in the table below, to allow a more accurate understanding of a student's affective response to a topic.

Table 2-5: Taxonomy of the Affective Domain: Responses and Examples

Category	Behavioural Response	Examples
Receiving	Being aware of or sensitive to the existence of ideas or topics and being willing to receive them.	Paying attention, compliance toward requirements, willingness to listen.
Responding	Actively responding to the ideas, materials, or topics of instruction.	Willingness to work on activities, self-starter, enjoyment, excitement, active involvement, satisfaction in topic and learning activities.
Valuing	Acceptance of the worth of a topic, showing advanced interest, high level of commitment to achieve, and expression of beliefs.	Seeking additional information, discussing it with others, working above and beyond requirements, drive and motivation to accomplish a task, expressing or advocating for a belief or value.
Organization	Conceptualization of values and organization of a value system. Creation of a hierarchy of values.	Comparison of personal values with new values, determining the position of new values with an internalized value system.
Characterization by a value or value complex	Acting consistently from an internalized, organized value system, and integration of values into a worldview.	Ability to consider issues and problems objectively, consistent code of behaviour showing respect and kindness in actions toward others.

Taken from: Krathwohl, David; Bloom, Benjamin; Masia, Bertram, taxonomy of educational objectives book 2/affective domain, 1st edition, © 1984:37, 95. Reprinted by permission of Pearson education, Inc., upper saddle river, NJ.

Krathwohl, Bloom and Masia (1964/1984) suggested that there was no separation between the affective and cognitive domains of learning and that emphasis on one tended to drive out the other. The present researcher's view in connection with Table 2.5 above is that learners gain appreciation of what they are learning about. In affective domain there are five characteristics that are very important and they relate to each other for a lesson to be successful. These characteristics are receiving, responding, valuing, organization and characterization by value or value complex. The domain encouraged educators to use relevant instructional strategies that would allow educational activities addressing the following: Paying attention when the educator starts the lesson as well as during the lesson.

The educators' approach of the lesson determines how the learners will receive the lesson. If learners receive the lesson positively then the teaching and learning becomes successful. When learners receive the lesson enthusiastically they will respond positively by participating in the lesson actively either working as individuals or working as groups. Participating in the lesson means the value of the lesson is treasured by learners and they will show that by asking questions, discussing and seeking clarity when necessary. Organization will be promoted since learners work together. They will be able to organize information so that it can be easy to read and understand it. Consequently, it will be easy for learners to consider issues and problems objectively. Again, they will be able to link the learned information with practical things in the society.

Psychomotor domain is a measure of the development of physical motor skills (Krathwohl, et al. 1964, 1984). Its practical part uses skilled movements and physical abilities. The present researcher is of the view that in this type of domain learners learn best by doing practical work. The researcher's view is confirmed by Howard Gardner in his theory of multiple intelligence. Gardner (2011) mentions that learners learn in ways that are identifiably distinctive and also states that it would be better if the disciplines could be presented in a number of ways and assessed using different approaches. Gardner (2011) highlights different ways of learning styles; amongst them are visual, spatial, bodily –kinaesthetic which uses movements and physical activity just like psychomotor domains. Bloom did not focus on or devise categories for skills in the psychomotor domain, but other educators have created their own psychomotor taxonomies (Simpson, 1972). Psychomotor objectives are as important to concentrate on as the Cognitive and Affective objectives within science education (Simpson, 1972).

Simpson (1972) states that psychomotor skills are essential in science and may include adjusting a microscope, preparing slides, manipulating apparatus and field work study. That means this domain emphasizes practical work that will motivate learners and enhance teaching and learning especially in science education since it involves experiments. As we learn more about how the brain learns and retains information, we begin to realize that targeted physical movement has the potential to enhance memory and recall and can aid in accelerating long-term memory (Anderson, et al. 2000). Hence, learning occurs effectively when the three domains are combined together, therefore learning becomes more holistic and multidimensional (Anderson, et al. 2000).

The present researcher's view concerning the three domains is that, they are relevant for assessment in promoting science learning and SL. For instance they have the key words (verb) that will direct on what needs to be done (cognitive domain) . Secondly a good approach on the lesson will make learners receive information positively and promote active involvement (affective domain) leading to their being able to do the practical part confidently (psychomotor domain). They can be combined when preparing the lesson and also fitted to the relevant instructional strategy. Furthermore, it is important to organize assessment tasks from the simplest to the more complex levels to cater for all learners in the classroom. Thus the original cognitive domain was revised to a new version which has more advantages than the old one. The new version has the new items and also the steps have been changed to verbs e.g. knowledge changed to knowing, application to applying, analysis to analysing. The verbs are the key words when compiling objectives of the lesson, they state clearly on how to achieve the specific topic.

2.14.2 Focus on assessments

Brookhart (2011) developed a framework with the key focus areas for educators to engage with quality assessment in science. These focus areas are explained below.

2.14.3 Focus 1: Focus on teaching

Thorough planning by educators enhances good assessment. For instance when educators are sure about the content they are going to implement in the class it makes it easy for learners to understand especially if educators are driven by a relevant methodology (Henze, Van Driel, & Verloop, 2008; Macugay & Bernardo, 2013). Hay and Penney (2012) mention that it is important to plan for assessment that is learning oriented, reliable, valid and socially just to enhance good teaching. Therefore, the present researcher concurs with the author referred to above and believes that using the cognitive domains when preparing assessment promotes teaching and learning effectively.

2.14.4 Focus 2: Focus on student

Educators are required to develop the skills to be able to design assessment tasks (which gather achievement evidence related to progress and/or mastery) bearing in mind their learners' aptitudes, prior learning and the context in which they are working in (Brookhart, 2011). Science educators need to focus on learners when preparing assessment and they must also cater for feedback in order to motivate learners to look forward to the results.

2.14.5 Focus 3: Focus on evidence learning

Focus on evidence learning is very significant for educators to be well informed and skilled in the use of assessment and know which forms of assessment are relevant for a particular activity (Hay & Penney, 2012). Hay et al. (2012) emphasized different methods that could be used by science educators to conduct assessment.

Table 2-6: Methods of collecting science teaching (Hay & Penney, 2012)

Method	Description
Observation	Educators observe the learners during an individual or group activity
Report	Learners produce an individual report or group report
Practical Investigation	Learners carry out practical investigation in groups.
Test	Learners participate in writing the task
Quiz	Learners participate in an oral quiz
Matching exercise	Learners participate in an oral or written match of text, pictures, shapes, designs etc.
Diagram	Learners draw an illustrative diagram
Explanation	Learners produce an oral or written explanation.
Seminar	Learners interact in an open discussion forum
Website	Learners look up, evaluate and extract information from a website or websites

Table 2.6 above shows the choices educators make when deciding what evidence to gather, and how to gather it, not only influence the classroom environment, but also

assessment validity and reliability (Hay & Penney, 2012). The present researcher is of the view that Table 2.6 serves more than one purpose e.g. as evidence of science learning and SL and also as methods of assessment that can be used by educators. Moreover, the methods of assessment can assist educators who are not clear about science teaching by guiding them on tasks to be done to evaluate the learned knowledge. Educators can also design the tool (rubric) to allocate marks for any form of assessment they will use. Hay and Penney (2012) mentions that good assessment can be designed to be authentic and valid, by taking into consideration students' strengths and interests. Subsequently, Penney (2012) highlights that some learners may be able to provide better evidence of their learning orally or by designing a web page, rather than by writing responses to examination questions or writing an essay. With regard to the statement above it may be concluded that learners' performance cannot be judged only by using examinations. Other forms of assessment can also be used and learners can master them.

2.14.6 Focus 4: Focus on assessment

Assessment needs to be authentic in order to focus on decision making, hence it is significant for educators to use their abilities to assist students to use assessment information to make sound decisions (Brookhart, 2011). For instance, when assessing practical work like observing the connections of the components of the circuit to assess whether it is series or parallel, the type of the assessment can motivate students to follow the science path for their careers. While educators have the authority to choose what is to be assessed and how it is going to be done, they must also ensure the validity of the assessment before it is conducted (Brookhart, 2011). The present researcher concurs with the author that it is the prerogative of the educator to be creative when designing an assessment activity, however, it must be aligned to the stipulated policy and principles of assessment.

2.15 Summary

Relevant literature was reviewed in examining educator's strategies for promoting science learning and SL among grade 9 learners. The literature was linked with research question and sub-research questions in order to ensure the connectivity between question items on all data collection instruments and the reviewed literature.

The main theoretical frame work for the study which was constructivism and its sub-sections cognitive constructivism and social constructivism were discusssed. The third theory of Shulman’s Pedagogical Content Knowledge (PCK) was added to cater for educators’ understanding about the content and how to transfer the content knowledge to learners. Research methodology is discussed in the next chapter.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter reviewed literature examining educators' strategies for promoting science learning and SL among grade 9 learners. This chapter consists of, amongst others, the following: the research paradigm; paradigmatic assumptions underpinning the study; research approach; research design; population and sampling; data collection instruments; validity and reliability; data trustworthiness; data collection procedures; data analysis and ethical considerations.

3.2 Research Paradigm

Lincoln, Lynham and Guba (2011), Creswell (2014) and Babbie (2012) concur that paradigm is essentially a frame of reference with which to observe and understand the world. Rubin and Babbie (2015: 37) define a paradigm as "an essential model or structure that organizes our view of something". Blance and Durrheim (2006) elaborate and state that a paradigm is an all-encompassing system of interrelated practice and thinking that defines researchers and the nature of their inquiry along three dimensions-ontology, epistemology and methodology. The present researcher is of the view that paradigm assists in answering the given research question. Literature notes that research paradigm has an impact on research methodology to be used in connection with the reasons why a researcher collects data, the type of data to be collected, site or sites of data collection and data analysis means and modes (Collis & Hussey 2003; Harrits, 2011). It is clear that paradigms underlie all efforts of theory building and knowledge production since they consist of all the main philosophical assumptions that guide research (Kezar & Dee, 2011). The present researcher is of the view that for authenticity of results, the study needs to be guided by the paradigm that will make the researcher accountable for the collected data and the results. This study followed post-positivist paradigm using mixed-methods which entailed quantitative and qualitative research approaches.

3.3 Research approach

Creswell (2007) and Johnson (2014) describe a research approach as a plan specifying the methods and procedure for research that spans the steps from broad assumptions for collecting and analysing the needed information in a research study. There are three main approaches to research that are commonly used namely: quantitative research, qualitative research and the mixed method approach research which is abbreviated as MMR (Creswell, 2007; Alzheimer-Europe, 2009).

3.3.1 Quantitative and qualitative approaches

3.3.1.1 Quantitative approach

In quantitative approach, the researcher adopts either a positivist or post-positivist perspective (Tashakkori & Teddlie, 2010). This approach investigates a phenomena using statistical, mathematical or computational techniques (Cortey, 2013; Zandvamari & Daryapoor, 2013). Quantitative research has historically been the cornerstone of social-science research. Purists call on researchers to "eliminate their biases, remain emotionally detached and uninvolved with the objects of study and test or empirically justify their stated hypotheses" (Johnson & Onwuegbuzie, 2004:14). Everest (2014) explains that the approach is believed to be helpful in testing and validating theories, testing hypotheses and replication of findings. One advantage of quantitative data analysis is that it uses the statistical software resulting in saving time and data coding is interpreted per each table. Creswell (2007, 2009) suggests that quantitative approach helps to present numerical analyses and to describe statistical relationships among variables. The present researcher uses this suggestion in this study.

3.3.1.2 Qualitative approach

In qualitative approach, the emphasis is on the meanings, traits and defining characteristics of events, people, interactions, settings or cultures and experiences (Everest, 2014). Burns and Grove (2003) define qualitative approach as an inductive, holistic, subjective and process-oriented method for understanding, interpreting, describing and developing a theory on phenomena. Dunlop (2013) concurs and posits that the qualitative approach seeks to understand human experiences, perceptions, motivations, intentions and behaviour by employing interactive, inductive, flexible and reflexive methods of data collection, analysis and interpretation. Creswell (2007) states that qualitative research is an inquiry process where a researcher develops a complex, holistic picture and reports detailed views of informants. Denzin and Lincoln (2005) explain that in qualitative research, the researcher approaches reality from a constructivist position, which allows for multiple meanings of individual experiences. The goal of qualitative approach is to explore and understand the central phenomenon which is the explored concept or process (Creswell, 2008). The main purpose of the qualitative approach is to examine and interpret social and human experiences. The present researcher asked broad open-ended questions which allowed the participants to share their views and experiences. The qualitative approach is inductive (bottom-up) and uses interviews, observations, case studies and video and audio tapes as instruments for data collection (Cortey, 2013). The present researcher used qualitative method when interviewing both educators and learners and during observation.

3.3.2 Mixed Method Research (MMR)

MMR is a useful research approach that refers to the use of two or more methods in a research project yielding both qualitative and quantitative data that call for real-life contextual understandings, multi-level perspectives and cultural influences (Creswell & Plano-Clark, 2007; Greene, 2007; Johnson, Onwuegbuzie, & Turner, 2007; Borrego, Douglas & Amelink, 2009; Teddlie & Tashakkori, 2009). As a methodology, it involves philosophical assumptions that guide the direction of the data collection and analysis and the mixing of qualitative and quantitative data in a single or series of studies. Its central premise is that the use of MMR provides a better understanding of research problems than through either quantitative or qualitative approach. The method is often referred to as dialectal stance that bridges positivist and social constructivist worldviews, pragmatic perspectives and transformative perspectives (Greene, 2007).

Creswell (2007) further explains that employing rigorous quantitative research, assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs are possible in MMR research. Creswell and Plano-Clark (2011) suggest three approaches: merging data, connecting data and embedding data. These will be applied in the study.

The benefit of the MMR approach in this instance is that the data produced by the different methods can be complementary. Denscombe (2010) states that MMR approach provides the researcher with the opportunity to check the findings from one method against the findings from another. Denscombe (2010) further mentions that the MMR approach is valuable for the development of research instruments. For example, researchers who are designing a questionnaire for use in a survey can employ qualitative data through interviews and Focus Groups (FGs) to improve the validity of a subsequent survey questionnaire that produces quantitative data (Denscombe, 2010). Furthermore, it is balancing the inherent weaknesses within one method with inherent strengths in the other resulting in well-validated and substantiated findings (Creswell, 2007, 2011).

MMR emerged as a distinct research methodology that evolved as a way of "converging and triangulating different quantitative and qualitative data sources" (Creswell, 2009: 204). Bryman (2007), Creswell and Plano-Clark (2007) and Denscombe (2008) indicate that this process helps to improve the accuracy of data and to produce a more holistic picture of the phenomenon under investigation. The strength of the MMR is that, it provides researchers with the ability to design a single research study that answers questions about both the complex nature of the phenomena from the participants' point of view and the relationship between measurable variables.

MMR approach was considered relevant for this study since it could provide the researcher with a vibrant picture of what to do or what steps to follow when collecting data on specific populations. MMR ought to generate deeper and broader insights about how educators are being supported for science learning and for promoting SL in rural schools. Through MMR, the present researcher also aimed to get data about examining strategies that promote science learning and SL. MMR allows for explanations of the approaches, opinions and practices of different participants. MMR was employed throughout the process of collecting and analysing the data, integrating the findings and drawing inferences within a single study as suggested by Tashakkori and Creswell (2007).

3.4 Research design

A research design is defined as a broad plan that specifies the methods and procedures for collecting and analysing the needed information (Kalaian, 2011). There are three commonly used non-experimental MMR designs in social research (Cortey, 2013; Creswell & Plano-Clark, 2007, 2011 and Tashakkori & Teddlie, 2006), namely, the explanatory sequential design, exploratory sequential design and the concurrent triangulation (parallel) design. Norman (2008) observes that concurrent triangulation design is used when the focus is on confirming, cross-validating or corroborating findings from a single study. During this study, quantitative and qualitative data were collected concurrently, such that weaknesses of one kind of data are ideally offset by the strengths of the other. It is deemed as most suitable when a researcher wants to collect both types of data at the same time about a single phenomenon in order to compare and contrast the different findings to produce well-validated conclusions (Creswell; 2007). In this design, no phase between QUAN and QUAL was prioritised over the other as priority could be given to either phase as suggested by Creswell (2009). The main purpose of the concurrent triangulation design was confirmation, corroboration or cross-validation within a single study as avered by Tashakkori and Teddlie (2006) and Terrell (2012).

A strength of the concurrent design is that the researcher can use concurrent timing by collecting and analysing quantitative and qualitative data at the same time (Ivankova, et al, 2006). Literature further states that mixed method can occur at the data analysis stage by either transforming qualitative themes and codes into numbers and then comparing those numbers with quantitative results, or by clustering the quantitative results and assigning them themes to compare with other themes that emerge from qualitative analysis (Ivankova, et al, 2006). Another strength of this approach is the ability to maximize the information provided by a single study, for example, when the interest is in cross-validation and a shorter data collection period compared to the sequential data collection approaches. Data are integrated during interpretation phase. Data integration can also occur during analysis. The interpretation notes allow convergence or divergence that strengthens knowledge claims.

Concurrent triangulation was selected in this study because of different reasons such as the use of separate quantitative and qualitative methods in a single-phase study. It planned to collect both numerical data and text (word) data concurrently and to choose variables and units of analysis which were most appropriate for addressing the study's purpose and finding answers to the research questions. The integration of data in the analysis was expected to make the interpretation more affluent. The present researcher expected to see the feedback on strategies that promoted science learning and SL from the participants through merging the two sets of data. The approach ought to allow the researcher to collect data on the strategies for science learning and promoting SL.

3.5 Population and Sample

3.5.1 Population

According to Creswell (2014), a population is the group which the researcher is interested in gaining information from and for drawing conclusions. It is any group of individuals, events or objects with one or more common characteristic(s) of interest to the researcher (Yount, 2006; Given, 2008; Babbie, 2009; Neuman, 2011).

3.5.1.1 Population of Circuits, schools, science classrooms, science educators and Grade 9 learners in the Education District

The decentralised nature of education administration and the selection of one district for the present study were alluded to in Chapter one under the sub-title 'methodology'. However, for the reader to recap, it is repeated here. In South Africa the education administration is decentralised through Provinces and education districts within each Province. Within each district there are education circuits.

The population of circuits in the selected education district was eight. Each circuit consisted of 6-10 schools and hence, the population of schools was 67. There was one science classroom and one science educator in each school and hence, the population of science classrooms and science educators was 67. The population of Grade 9 learners was 2527 (1011 Boys & 1516 girls) in all schools in the selected education district.

3.5.2 Sample of Circuits, schools, science classrooms, science educators and Grade 9 learners for the study

Sampling is a procedure of choosing participants to play a role in a research study to elucidate facts considered significant to the research problem (Yin, 2013). Neuman (2008) defines a study sample as a collection of elements drawn from the population that is studied.

The district identified for the present study was chosen because it was the nearest to the place of work of the present researcher (convenience sampling). Out of the eight circuits in the district, those circuits which shared large geographical borders with each other were six. The school Principals were prepared to allow data collection only in the first quarter of the academic year (January to March). The roads in this rural education district are untarred and become very muddy when it rains and rains are common in the first quarter. For data collection, the study used convenient sampling based on proximity to the researcher and comparative ease to reach the rural schools to select 30 out of 67 schools spread over six out of the eight circuits in the selected education district. Out of these six circuits, data were collected from three to six schools' per circuit and so, schools' sample was 30.

Since each school had only one science classroom and only one Grade 9 science educator, there were 30 science classrooms and 30 Grade 9 science educators in the selected schools. No sample selection was required since the ones who were teaching were willing to participate in the study and was prepared to sign the informed consent form. Thus, 30 educators were in the educators' sample. They all participated in completing the questionnaire. However, when the present researcher requested for about 45-50 minutes for interview and permission to observe their classrooms, only 10 out of them were willing and as such only 10 educators formed the qualitative sample who were interviewed and the classrooms of the same 10 educators were also observed.

For learners, purposive sampling was used based on recommendation from the science educators in each of the selected schools. They were requested to select three learners, top, average and below average in science from their respective schools. The criteria for seleting the learners was based on their academic achievement. Learners were involved in the study through FGs. Three learners in each of the 10 schools from which the educators for qualitative data collection were selected, constituted the learners' sample of 30 learners who were grouped into 10 FGs with three from each school in one FG.

The summary is given in Table 3.1 below.

Table 3-1: Summary of population and Sample

Participants/ respondents type	**Population**	**Quantitative Sample**	**Qualitative Sample**
Science Educators	67	30	10 educators, one from each of the selected schools
Grade 9 Science learners	2527 Boys:1011 Girls: 1516	0 0	30 learners, three from each of the selected 10 schools.

3.6 Instruments of data collection

The present researcher constructed four instruments. These were one quantitative-a questionnaire (Appendix F)- and three qualitative instruments: an interview schedule for educators (Appendix G), an observation recording template (Appendix H) and an interview schedule for FGs (Appendix I). They were validated through feedback from two NS specialist: subject education specialist (SES) and science teacher. Subject education specialist refers to a person who support educators in schools based on their areas of specialisation (Collective agreement 1 of 2008: Annexure A). Furthermore, through feedback from a pilot study, the instruments were modified. Reliability and validity were also established.

While data were collected through questionnaires, interviews and observation from educators, data from learners were collected through FG interviews. The Questionnaire had two sections: Section A which sought biographical information and Section B which sought data on each of the five research sub-questions through completion of tables and some open-ended questions. In Appendix F, the focus areas were: the strategies educators employ when teaching; the strengths and weaknesses of their strategies; strategies relevant to promoting science learning and SL; the support educators get to teach science and SL effectively and assessment strategies which educators implement in the science classrooms. The estimated time to complete the questionnaire was about 1 hour.

The interview schedule for educators (Appendix G) had five questions which were linked to the five research sub-questions, followed by open-ended questions for probing. Each interview was planned for 45 to 50 minutes. Both the interview schedule and the questionnaire for the educators had the same focus reas.

Observations of educators: The same 10 educators who were interviewed also had agreed to be observed. Appendix H served as a guide to the researcher. The observation template guide had seven criteria of observations. The information was linked to the sub-research questions and the three strategies were focused upon in the observations. The lesson observation had to happen during the time-tabled lesson periods using times that the participants were flexible with. The class period duration was 50 minutes and the researcher sat in the class from beginning to the end.

Observations followed interviews since the present researcher wanted to find out if the strategies which educators claimed to be using were indeed part of their classroom activities. Observations focused on strategies used by educators in the lesson for science learning, SL and assessments thereof and included science inquiry, Predict-Observe-Explain strategy and technology integration. There were some challenges during educator observations such as learners' inability to fully participate in the class activities due to over-crowding, old and broken furniture and broken glass windows which allowed cold air to flow in. In such environments, teaching and learning of science cannot be effective. The focus areas were: teaching strategies and activities which the educators employ in class to promote science learning and SL; teaching and learning materials they use; the use of technology intergration and application of good principles of assessment. The present researcher faced challenges with some of the educators during data interviews. Some educators were not ready for interviews and postponed timing despite pre-set appointments or were absent without notifying the present researcher. However, the task was completed.

The instrument for the FG interviews (Appendix I) also had five questions linked to the five research sub-questions with additional questions for probing. Each FG interview was planned for 40 to 45 minutes.

3.6.1 Using quantitative data collection instruments

The section deals with the statistical analysis and numerical data to provide quantitative information (Thietart, 2007). The two authors also mentioned that quantitative research requires objectively evaluating the data which consist of numbers and trying to exclude bias from the researcher's point of view. Furthermore, quantitative method makes use of questionnaires. A questionnaire according to Given (2008) is a method of collecting data that consists of a series of questions and other prompts for the purpose of gathering information from respondents. A questionnaire leads to higher response and more accurate data than any other data collection instrument (Mathers, et al. 2009). Denscombe (2010) states that questionnaires consist of a written list of questions. Denscombe(2010) further mentions that each person who answers the particular questionnaire reads an identical set of questions as this allows for consistency and accuracy in terms of the wording of the questions and makes the processing of the answers easier (Denscombe, 2010).

3.6.2 Using Semi- structured questionnaires

Semi-structured questionaires are questionnaires which include a combination of both structured (closed-ended) and unstructured (open-ended) sections within the same questionnaire (Zohrabi, 2013). It is an instrument that is designed in a way that allows for open ended questions. A yes or no question is followed by a prompt question in oder to elaborate more about the issue.

3.6.2.1 Strengths of semi-structured questionnaires

The first advantage relates to gaining access to remote subjects as a questionnaire allows a researcher to gather data from any part of the world any time (Timpany, 2011 & Yount, 2006). Questionnaires allow the respondents to complete them at their own convenience, while allowing some time to think about their answers. Wilkinson and Birmingham (2003) highlight the advantages of questionnaires as: the availability of a number of participants in a place enabling economy of time, expense and providing a high proportion of useable responses. They are reliable data gathering tools in the sense that the selected participants get the opportunity to give honest feedback since they fill in the questionnaires privately.

3.6.2.2 Weaknesses of semi-structured questionnaires

Wilkinson and Birmingham (2003) and Denscombe (2010) mention that questionnaires often provide low responses (return rates), time consuming follow-up and data entry. Lack of adequate time to complete the instrument may result in the return of superficial data. There are costs involved in distributing, collecting, printing and data analysis.

3.6.2.3 Justification of using semi-structured questionnaires

The present researcher used open and closed ended questions. Denscombe (2010) explained that closed questions structure the answers by allowing only answers which fit into categories that have been established in advance by the present researcher. The answers provide pre-coded data that can easily be analysed. They allow the present researcher to gather information from a large number of participants and data collected through questionnaires is reliable.

3.7 Using qualitative data collection instruments

Concerning qualitative data collection, the researcher used interviews, FGs and observations.

3.7.1 Semi-structured interviews

Neuman (2008) defines a research interview as a way of collecting data and gaining knowledge from individuals and this allows the interviewer to probe the interviewee further for clarification. Interviews can be structured as semi-structured or unstructured, and the present researcher in the study used the semi-structured interviews since they are relevant for the study. Literature shows that semi-structured interviews are useful in that the interviewer gives out unconscious signals that may guide the respondent on the type and nature of response to give (Mathers et al. 2009;

Phellas, et al. 2011). A semi-structured interview is characterised by a series of open-ended questions based on the topic the researcher wants to cover (Adejimi, Oyediran & Ogunsanmi, 2010; Mathers, et al, 2009 and Phellas, et al. 2011). The statement above is concurred by Denscombe (2010) by highlighting that semi-structured interviews answers open-ended questions and there is more emphasis on the interviewee elaborating points of interest. The structure of a semi-structured interview is usually organized around an interview guide containing topics, themes or areas to be covered during the course of the interview, rather than a sequenced script of standardized questions (Berger, 2010; Mason, 2004; Pathak & Intratat, 2012).

Semi-structured interviews allow respondents to talk about a phenomenon in detail and depth, thus ensuring that meanings behind an action are revealed, as the interviewees speak for themselves with little direction from the interviewer (Mathers et al. 2009). It is easy to record (video or audiotapes). The interview schedule for educators addressed the strategies used by educators to promote science learning and SL.

3.7.2 Strengths of semi-structured interviews

Literature gives detailed benefits of semi- structured interviews as follows: They assist in clarifying concepts and problems and they allow for the establishment of a list of possible answers or solutions which in turn facilitates the construction of multiple-choice questions (Bless & Higson-Smith as cited in Adam, 2010 and Cohen et al. 2007). In addition, Denscombe (2010) stated that an advantage of semi-structured interviews is that the researcher is likely to gain valuable insights based on the depth of the information. Concerning validity, direct contact during interviews means the data can be checked for accuracy and relevance as they are collected. In the study the present researcher compiled the interview schedule and it is relevant to sub-research questions. Both educators and learners were given the opportunity to to interact face to face and interviews were successful.

3.7.3 Weaknesses of the semi-structured interviews

Denscombe (2010) mentions that although there are strengths in semi-structured interviews, there are also some weaknesses such as:

- Time factor - Analysis of data can be difficult and time consuming. The transcribing and coding of interview data was a major task for the researcher, which occured after the data had been collected.
- Interview effect – The data from interviews are based on what people say rather than what they do. The two may not tally for instance what people say they do, what they say they prefer and what they say they think cannot automatically be assumed to reflect the truth.
- Resources – With face to face interviews the costs of interview time and travel can be relatively high, particularly if the respondents are geographically dispersed.

Adam (2010) explains the weakness in semi structured interviews as: difficulty to record responses, particularly if the interviewer is also responsible for writing them down. To minimise the weakness the researcher took notes while recording the interviews.

3.7.3.1 Justification for using semi-structured interviews

The present researcher sees the semi structured interviews as the type of interviews that fit very well with the study as they have more advantages. They allow the participants to be more relaxed in answering the questions. They give in-depth information about examining strategies that will promote science learning and SL among grade 9 learners.

3.8 Using lesson Observations

According to Cohen, Manion and Morrison (2007) observation is a way of gathering data by watching behaviour or events as well as noting physical characteristics in their natural setting. Observation methods are useful to researchers in a variety of ways. They provide researchers with ways to check for nonverbal expression of feelings, determine who interacts with whom, grasp how participants communicate with each other and check for how much time is spent on various activities. Lesson observations allow one to directly see what people do without having to rely on what they say about their actions. Denscombe (2010) states the purpose of the schedule as a tool to minimize and possibly eliminate the variations that will arise from data based on individuals' perception of events and situations. In addition, the author emphasizes that the schedule provides framework for observations which all observers will use and will enable them to do the following when observing, that is, record data systematically and thoroughly. There are things that are very important when observing, i.e., things to be observed need to be overt, obvious, relevant, complete, precise and easy to record (Denscombe, 2010). They are explained below:

Overt: The researcher should make sure that items observed should involve open behaviour which is observable and measurable in a direct manner. The author further mentions that in the overt, things like attitudes and thoughts need to be concluded by the researcher, since they are not observable in a direct manner.
Obvious:The observation notes should require a minimum of interpretation by the researcher.
Relevant: During observations, what to be investigated concerning the study should be relevant.
Complete: The researcher should make sure that the observation schedule covers all the possibilities to avoid errors while observing.
Precise: There should be no ambiguity about the categories and observations need to be defined precisely and there should be no overlap between them.

Easy to record: observations should occur with sufficient regularity and sequence for the observer to be able to log the occurrences accurately and fruitfully.

The present researcher aligned the schedule as suggested by Denscombe (2010) and made use of observation schedules for lesson observations.

3.8.1 Using participant observation of lessons

Participant observation is a specific technique to collect data and Sandiford (2015) avers that in the case of observations, participant observations are useful. The participant observer becomes close to the research subject in order to do probing of questions when explanations are needed (Spradley, 1980). Sharing the guidance from these two authors, the present researcher personally observed the educators in their respective classrooms while they were teaching. The probing of questions facilitated clarity.

The present researcher used participant observations to gather data e.g. observing lessons while they were taught. The aim was to see if the expected strategies were really employed to enhance science learning. Since the educator was teaching, the present researcher observed the strategy used and if learners were participating in the lesson. The researcher also observed if the educator promoted constructivist approach in the classroom.

3.8.2 Strengths of participant observations

Participant observation is characterized by actions such as an open and non-judgmental attitude, showing interest in learning more about others. They provide first-hand experience, especially if the observer participates in activities. One ought to be a careful observer, a good listener and open to the unexpected in what is learned (Dewalt & Dewalt, 1998). Demunck and Sobo (1998) point out that observations allow for richly detailed descriptions. As such, observations can provide relatively objective measurement of behaviour especially for standardized observations.

3.8.3 Weaknesses of participant observations

Demunck and Sobo (1998) also share several disadvantages of using participation as a method, including that sometimes the researcher may not be interested in what happens out of the public eye and that one must rely on the use of key informants. Sampling of observed people and settings may be limited. Some settings and content of interest may not be observed.

3.9 Using FG interviews

FG is a small group of people, who are brought together by the researcher to explore attittudes and perceptions, feelings and ideas about the topic (Denscombe, 2010). Kamberelis and Dimitriadis (2013) state that through FGs, the researcher creates better approximations to natural interactions than would in individual interviews. They are useful for exploring ideas and concepts, and allows for probing questions. FG interviews consist of tape recordings or transcripts of discussions concerning a set of questions on a specific phenomenon selected by the researcher and may be used especially as a qualitative technique for collecting data (Mhlongo, 2011). They allow the participants to jointly produce accounts about the topics of interest in a socially organized situation. Participants and the moderator are “operating under the shared assumption that the purpose of the discussion is to display opinions to the moderator” (Myers, 1998: 85). Moreover, Myers (1998: 85) states that this type of interview is conducted after a series of individual interviews to further explore the general nature of the comments from different individuals. FG interviews allow observations of group interaction in controlled settings (Mouton, 2001). Furthermore, they provide a window into the participants’ internal thinking and obtain in-depth information. Denscombe (2010) highlighted three characteristics of FGs namely:

(a) Prompt/stimulus–It is a session that revolves around a prompt, a trigger. The same stimulus was introduced by the researcher in order to focus on the discussions;
(b) Moderator not a neutral person-There is less emphasis on the researcher to adopt a neutral role in the proceedings than is normally the case with other interview techniques;
(c) Interaction within the group-Interaction between group members is given a value and their views are given a priority.

3.9.1 Strengths of FGs

Babbie (2009) maintains that FGs help in explanatory studies. Marshall and Rossman (2011) mention the advantages of FGs such as having socially oriented participants studying in an atmosphere that is natural rather than artificial. The above researchers further mentioned that FGs allow socially oriented research that captures real life in a social environment. When combined with participant observations, FGs are especially useful for gaining access, focusing on the site, selection and sampling. The present researcher is of the view that FGs allow the participants to be honest about the teaching and learning in the classroom. Therefore, it is easy to identify the gaps between the learners and the educator. Furthermore, the FG group members feel freedom to express themselves without the educator listening to what they state.

3.9.2 Weaknesses of FGs

Patton (2002) states that there are weakenesses in FGs and they are reliant on group interaction that may at times be dominated by one or two participants. Babbie (2007) notes that a researcher has less control over group discussions compared to individual interviews. This researcher also points out that FGs may yield data that can be difficult to analyse without appropriate skills to manage them. Babbie (2009) also cautions that FGs can be time consuming due to the time lost while members raise or talk about indirectly relevant or irrelevant issues.

3.9.3 Justification for using FGs

The FGs were used to assist the present researcher to answer the research questions on examining strategies for science learning and promoting SL. The FG interviews can reveal how the educators deliver the lesson. This can assist the present researcher to receive the evidence from them immediately and directly through voice recorded responses and hand-written notes.

3.9.4 Data analysis

Descriptive statistics was used to analyse quantitative data. The qualitative data from open-ended questions from each participant and each FG were organised in order to pick up the contribution to sub-themes in relation to each of the sub- and main research questions and their links to the main question (thematic analysis).

3.10 Validity and reliability

3.10.1 Validity

Validity ensures that the instrument measures what it is designed for. Burns (1999:160) stresses that "validity is an essential criterion for evaluating the quality and acceptability of research." The quality of the instruments is very critical for the reason that "the conclusions researchers draw are based on the information they obtain using these instruments" (Fraenkel & Wallen, 2003: 158). Validity helps to augment not only the appropriateness, meaningulness and usefulness of the items in the instrument but also the inferences the researchers can make based on the data they collect (Fraenkel & Wallen as cited in Maponya, 2010). This study ensured content validity. In order to guarantee content validity, the research instruments were evaluated by two NS subject education specialist in the field of science: subject education specialist and a science and technology senior educator. This study also ensured validity of the data collection instruments by pilot testing the instruments.

3.10.2 Reliability

Reliability deals with the consistency, dependability and replicability of “the results obtained from a piece of research” (Nunan, 1999:14). Magwa and Magwa (2015) state that reliability means that the measuring instrument must be stable and must consistently produce the same measurements over a period of time. Lincoln and Guba (1985: 288) point out that instead of obtaining the same results, it is better to think about the dependability and consistency of the data. In this case, the purpose is not to attain the same results but rather to agree that based on the data collection processes the findings and results are consistent and dependable. Cronbach alpha test is considered as useful to ensure reliability.

3.10.2.1 Cronbach’s alpha test

George and Mallery (2003) clarifies that the outcomes of Cronbach’s alpha are interpreted generally as rule of thumb.The Cronbach alpha value helps to assess the internal consistency of the quantitative measuring instrument. The test was used to ascertain the scale reliability of the questionnaire. The operations of the alpha are such that if the components of the instrument display strong correlation with one another, then it can be concluded that internal consistency is high (Coetzee, 2017). The values range from 0 to 1. The higher the value, the more acceptable the reliability will be. Nonetheless, the acceptance is not set upon the ascendancy from 0 to 1. The interpretation and generally accepted decision rules of Cronbach’s alpha are that outcomes ≥0.7 are acceptable as indicating the presence of internal consistency. George and Mallery (2003) state that values greater than 0.9 are generally considered as showing excellent internal consistency; 0.8 showing good internal consistency; 0.7 showing acceptable internal consistency; 0.6 showing questionable internal consistency; 0.5 showing poor internal consistency and anything below 0.5 showing general unacceptabitlity.

The Table below illustrates the outcomes of the Cronbach’s alpha test for the quantitative instrument in the present study.

Table 3-2: Cronbach’s alpha reliability of internal consistency for Likert-scale

Reliability Statistics			
	Themes	Cronbach's Alpha	No of Items
PART 1	Strategies used by educators to teach Natural science curriculum	0.936	14
PART 2	Strengths and weaknesses of each of the following strategies in promoting SL	0.448	14
PART 3	Strategies used to support educators to promote SL.	0.936	14
PART 4	Strategies that are most relevant in enhancing SL.	0.703	14
PART 5	Strategies educators use to assess students' SL.	0.368	10
	Instrument	0.911	64

Cronbach's alpha for the instrument is shown as 0.911. This can be interpreted as an indication of high reliability and internal consistency in the questionnaire.

3.11 Pilot study

The pilot testing was conducted with two FGs (each having three learners) and two educators. Pilot study is essentially a feasibility study of the tools and the process of implementing them (Kumur, 2011). The researcher was using questionnaires and interviews with educators and FGs with learners. Observations were also used with educators. The researcher was satisfied with the feedback from interviews and observation tool. The challenge encountered in the questionnaire was that there were questions that were not clear. With the help of my Supervisor, modifications were carried out.

Table 3-3: Improvements on data collection instruments after pilot study

Type of instrument	Nature of correction effected	Item before pilot testing	Item improvement after pilot testing
Questionnaire	Adding open ended questions	It was closed questions only	Mention any other strategy you use that are not in the list. Mention any other strategy you know that are not in the list. Write down the strength and the weakness of that strategy. Mention any relevant strategy that is not on the list Justify your choice of: Most relevant

3.12 Data trustworthiness

The following measures were taken to ensure data trustworthiness of the study: Member checks of interview transcripts, Multiple sources of data collection, Pilot testing of instruments, Data audit and Description of research context.

Data trustworthiness can also be ensured by checking credibility, dependability, transferability and confirmability. Lincoln and Guba (1985) quoted in Babbie and Mouton (2012:276), observe that the key principle of good qualitative research is the notion of trustworthiness. It is not necessary to treat dependability as a separate entity to credibility in the study as they perform the same function. In this study the present researcher addressed dependability by making sure that it is explained in detail how data would be collected to make sure that the results were consistent with the data collected. The present researcher was aware she was responsible for gathering the data, interpreting them and coming up with authentic findings. Furthermore, the data were organized in a sequential order so that it would be easily accessible when needed. Concerning member checks of interview transcripts, the researcher would allow permission to the participants to check the interview scripts, read them and correct mistakes. For multiple sources of data collection, the researcher used triangulation of sources. The present researcher also wrote down notes on all the participants' responses. The present researcher read back the responses to participants to confirm the authenticity of the responses. Data collected were transcribed within three days while the information was still fresh.

3.13 Credibility

Credibility is based on actions taken by a researcher during fieldwork. According to Babbie and Mouton (2012) and Creswell (2007) credibility is addressed through the following procedures: engage in fieldwork until data saturation occurs (Babbie & Mouton, 2012). In addition, Creswell (2007) and McMillan and Schumacher (2010) point out that the extended fieldwork allows interim data analysis, the verification of findings and what happened in a real life situation. The researcher spent sufficient time with the participants in order to get to know them, to build trust and rapport and concurrently gathered data until it reached saturation. The techniques used to ensure credibility also established the notion of dependability in a qualitative study.

3.14 Dependability

Dependability is an assessment of the quality of the combined process of data collection, analysis, interpretation and theory generation (Lincoln & Guba, 1985). Anney (2014) and Yin (2011) stress that dependability can be recognised using audit trail, code-recode, overlapping methods and ensuring that the processes are reported in detail to enable future researchers to repeat the work or gain same results. The present researcher is aware that she is accountable for gathering the data and interpreting it so that good quality research findings are produced. In the study the research design and its application were sufficiently explained.

3.15 Transferability

Transferability implies the extent to which the findings can be employed in other settings, engaging different participants (Babbie & Mouton, 2012). Although transferability is dependent on the interpretations and understanding of the participants of the research study, Babbie and Mouton (2012) further maintain that qualitative researchers are not primarily interested in generalizing the results.

However, the researcher gave detailed research methods, contexts and assumptions underlying the study. The present researcher improved transferability by providing clear details on the research methods that were employed in the study.

3.16 Confirmability

Confirmability is the degree to which the findings are the product of the focus of the inquiry and not of the biases of the researcher (Babbie & Mouton, 2012). In simpler terms, there must be evidence of all fieldwork occurrences and not the researcher's assumptions. That means confirmability is the degree to which the results could be confirmed by others, especially the participants of the study.

3.17 Measures to ensure data trustworthiness

To ensure trustworthiness the present researcher adopted a number of measures like credibility, transferability, dependability and confirmability. Quantitative research considers reliability, objectivity and validity while in contrast qualitative research considers dependability, credibility, transferability and confirmability as trustworthiness criteria as suggested by Anney (2014). In order to ensure credibility, participants were given a chance to refuse participation if they were unwilling to participate voluntarily. To ensure transferability, measures for selecting participants were clearly expressed to confirm relevant people were chosen to contribute and to see to it that enough time was given to provide data. To ensure dependability and confirmability, measures such as voice recording for interviews was done and hand-written transcripts were kept for possible verification if needed.

3.18 Process of data collection

Quantitative data collection from educators: The present researcher personally delivered one questionnaire (Appendix F) to each of the 30 educators and they were requested to complete it within seven days. However, when the present researcher went to collect them, only 16 had completed them. The remaining educators were reminded to kindly complete within another four days and the present researcher returned to collect them. Fortunately, the late ones were also completed as requested which made a return rate of 100%. The main challenge was that the present researcher had to travel 70 km from the work place to the education district office and travel further about 30 to 60 km from there to the schools amidst bad weather and untarred roads.

Qualitative data collection from educators: As explained in the population and sampling sub-section earlier, only 10 educators were interviewed using Appendix G. They were interviewed during the times when they were free from teaching such as break-time and after school. Each interview took about 45 minutes to complete. With their permission, the interviews were also voice recorded. The main focus areas were: the strategies educators employ when teaching; the strengths and weaknesses of these strategies; strategies relevant to promote science learning and SL; the support which educators get to teach science effectively and the assessment strategies which educators implement in the science classrooms.

Observations of educators: The same 10 educators who were interviewed had also agreed to be observed. Appendix H served as a guide to the researcher since the lesson observation had to happen during the time-tabled lesson periods using times that the participants were flexible with. The class period duration was 50 minutes and the researcher sat in the class from beginning to the end. Observations followed interviews since the present researcher wanted to find out if the strategies which educators claimed to be using were indeed part of their classroom activities. There were some challenges during educator observations such as learners' inability to fully participate in the class activities due to over-crowding, old and broken furniture and broken glass windows which allowed cold air to flow in. In such environments, teaching and learning of science cannot be effective. The main focus areas were: teaching strategies and activities which the educators employ in class to promote science learning and SL; teaching and learning materials they use; the use of technology intergration and application of good principles of assessment. The present researcher faced challenges with some of the educators during data interviews. Some educators were not ready for interviews and would postpone when the appointment was already done, or they were absent without notifying the present researcher.

Qualitative interviews for learners' FGs: 30 learners, three learners from each of the 10 schools volunteered to be in FGs and voice-recorder and this constituted 10 FGs using Appendix I. The main focus was for them to share their experiences in science class teaching e.g. use of technology intergration during the lesson, strategies used by educators to teach them, different types of assessment they use in science tasks, the type of support they get from different stakeholders and the relevance of science they learn at school linking with their environment. A challenge in connection with learners were that they were in a hurry to go home after school since they use different transport like public transport and contract transport. Sometimes the present researcher took more than two days to complete the interviews.

3.19 Data Analysis

Green (2007), Creswell and Plano-Clark (2011) and Tashakkori and Teddlie (2010) explain that mixed methods data analysis requires knowledge of strategies for analysing quantitative and qualitative data. The present researcher used MMR research approach whereby the three types of data were combined, that is, quantitative, qualitative and voice-recorded data.

3.20 Analysis of Quantitative data

Statistical analysis of quantitative data was done with Statistical Package for Social Sciences (SPSS) version 21. In each strategy, frequencies and percentages were used to analyse and describe the data as suggested by (Migiro & Magangi, 2011).The correlation coefficient, often referred to as the Pearson correlation coefficient, is a measure of the strength or degree of linear association between two variables. The test is useful given the assumption of a linear relationship between the variables (Maree, 2018). The correlation analysis reveals three components of the relationship between the variables i.e. the direction of the relationship, the strength of the relationship and then whether the association is statistically significantly different from zero. The conclusion of statistical significance of the correlations will be determined by p-values which are less than 0.05. Pearson correlations resultantly lie between -1 and +1 as minimum and maximum respectively. Values nearer to -1 are considered to indicate strong negative relationships while those closer to +1 indicate strong positive relationships. Values revolving closer to the zero mean would indicate weak correlations (Verbeek, 2013). The study employed non-directional (2 tailed) hypothesis tests:

$$H_0 : \rho = 0$$

$H_1 : \rho \neq 0$

3.21 Analysis of Qualitative data

Ibrahim (2012) and Vaismoradi, Turunen and Bondas (2013) describe thematic content analysis as a process that involved cutting across data in search for patterns and themes by giving all units of data a particular code. The qualitative data from open-ended questions from each participant and each FGs were organised in order to pick up the contribution to sub-themes and main themes in relation to each of the sub-research questions and their links to the main question (thematic analysis). Similar ideas were grouped together. Interview data from recordings were transcribed and coded. Verbatim quotes from participants were isolated to support the themes and sub-themes and were first categorised and captured on a broad chart in order to capture the data from all participants. Pertinent common data were isolated to generate answers to the research sub-questions and main research question. The process allowed drawing of insightful conclusions.

3.22 Research ethics

Abongdia (2013) explains that doing research today without consent being sought from all participants may result in the questioning of the validity of the results and knowledge claims that might come from the research. Therefore, it is the researcher's duty to protect the integrity of participants. The present researcher's task is to ensure that participants have a complete understanding of the purpose and methods to be used in the study, the risks involved and the demands placed upon them as participants (Best & Kahn). The following ethical issues were addressed in the study.

University of Fort Hare granted ethical clearance for the research (Reference number MAM061SMTS01-Appendix B). Furthermore, the Provincial Education Department granted permission (Appendix A). Based on these, the District Education office allowed access to the schools to collect data. Before data were collected, educators in the sample were requested to sign Informed Consent Forms. Those learners in the FG who were above 18 were requested to sign the Informed Consent forms but four learners aged below 18 were requested to get the forms signed by one of their parents or guardians and they complied. Fortunately, the parents of the four learners were literate in English, there was no need to produce informed consent forms in the vernacular.

3.22.1 Anonymity and confidentiality

The respondents were told that their responses would remain anonymous, confidential and their names would not be written even if findings were published. As such, the respondents and the school were coded.

3.22.2 Avoidance of harm

The present researcher guaranteed that no participant would be put in a situation where they might be harmed and risked as a result of their participation in the study. The environment was safe since the participants were in the school setting , responding to questions.

3.23 Summary

Chapter three focused on the research methodology for this study. The study is located within the pragmatic paradigm adopting the MMR approach and directed by the concurrent triangulation research design. The population, sampling methods and data collection instruments were addressed. Multiple data collection techniques such as semi-structured questionnaires, interviews and observations were employed to ensure that quantitative and qualitative data were collected.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

The purpose of the study was to examine educators’ strategies for promoting science learning and SL among grade 9 learners. The previous chapter deliberated on methodology. The current chapter presents the data collected, analysed and discussed. Semi-structured questionaires were administered to educators. The questionaire consisted of a section with biographical information of educators. It covered the five parts of the guiding research questions which were: Strategies used by educators to teach natural science curriculum, strengths and weaknesses of the strategies that promote science learning and SL, strategies that are used to support educators to promote science learning and SL, strategies that are relevant in enhancing science learning and SL and strategies educators use to assess learners for science learning and SL. The educators’ interview transcripts provided the qualitative data.The two sets of data (quantitative and qualitative) were analysed and triangulated during the interpretation phase.

Table 4-1: Biographic characteristics of respondents and participants

Biographic variable	Variable description	Frequency	Percentage%
Gender	Male	16	53.3
	Female	14	46.7
	Total	**30**	**100.0**
Age	Below 30	5	16.7
	30-39	4	13.3
	40-49	16	3.3
	50 and above	5	16.7
	Total	**30**	**100**

Highest academic qualification	Educators' diploma	13	43.3
	Bachelor's degree	14	46.7
	Honours degree	1	3.3
	Masters	1	3.3
	Other (PGCE)	1	3.3
	Total	**30**	**100.0**
Position in school	Subject educator	24	80.0
	Class educator	3	10.0
	Head of department	1	3.3
	Senior educator	1	3.3
	Principal	1	3.3
	Total	**30**	**100.0**
Teaching experience	0-2years	4	13.3
	3-5years	3	10.0
	6-8years	4	13.3
	9-11years	3	10.0
	12+	16	53.3
	Total	**30**	**100.0**
Teaching experience in Natural sciences	less than a year	4	13.3
	1-5years	9	30.0
	6-10years	10	33.3
	11+years	7	23.3
	Total	**30**	**100.0**
Employment condition	Temporal	6	20.0
	Permanent	24	80.0
	Total	**30**	**100.0**

In the rural district in the Eastern Cape Province of South Africa, the educator population was skewed as 25.4% and 74.6% for males and females respectively. StatsSA (2013) which is the main governmental statistical body had reported that the sampled schools had varying population dynamics. This variation may not have any significant impact on the responses and information gathered.

Table 4.1 shows that males and females were 16 (53,3%) and 14 (46,7%) respectively, indicating gender balance in the sample. This is also illustrated diagramatically in the pie chart in Figure 4.1. Of these educators, 6 (20%) and 24 (80%) were temporarily and permanently employed respectively.

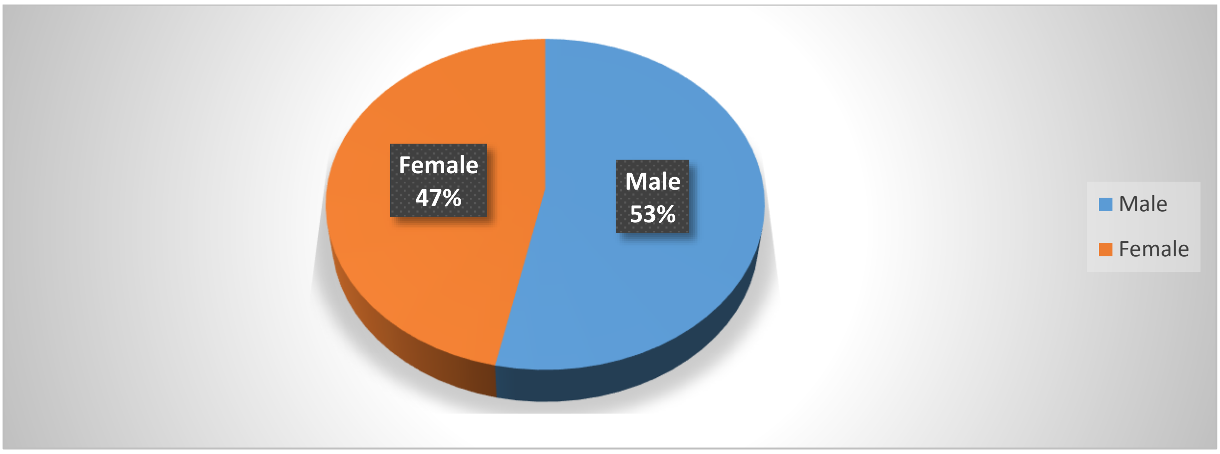


Figure 4-1: Gender Distribution of educator respondents

Table 4.1 and Figure 4.1b also show that the majority or respondents were holders of educator diplomas (13 or 43,3%) and Bachelors degrees (14 or 46,7%) constituting a total of 90%. The respondents with qualifications beyond the bachelors' degree were distributed as 1 (3.3%) each for honours, Masters and PGCE (Postgrsaduate Certificate in Education).

Table 4.1 and Figure 4.1c illustrate the distribution of professional positions currently held by the respondents. These were distributed as 24 (80%) and 3 (10%) for subject teacher and class teacher respectively. This is indicative that most of the respondents held low entry level positions in their work stations. The remaining 10% held the positions of Head of department, senior educator and principal.

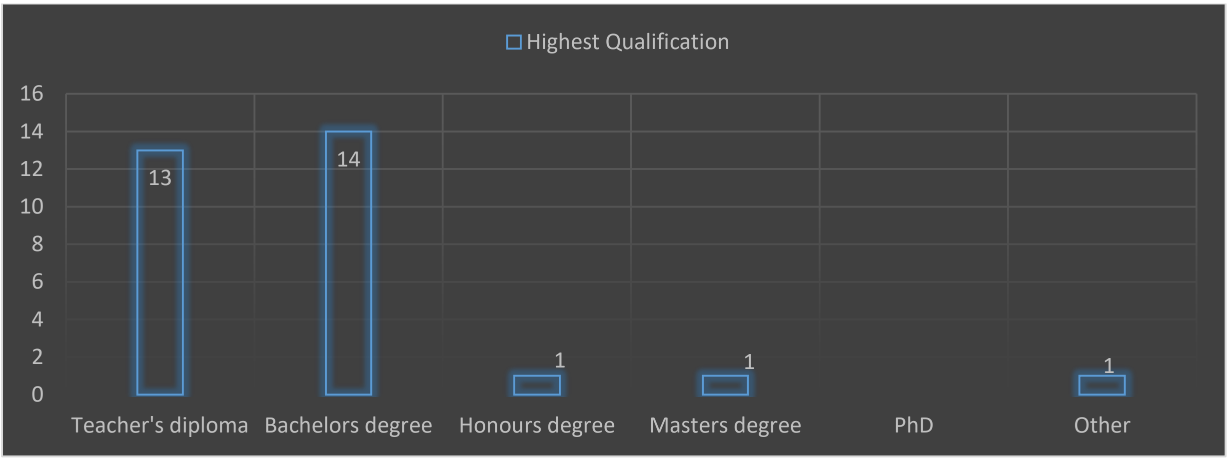


Figure 4-2: Respondents' highest qualifications

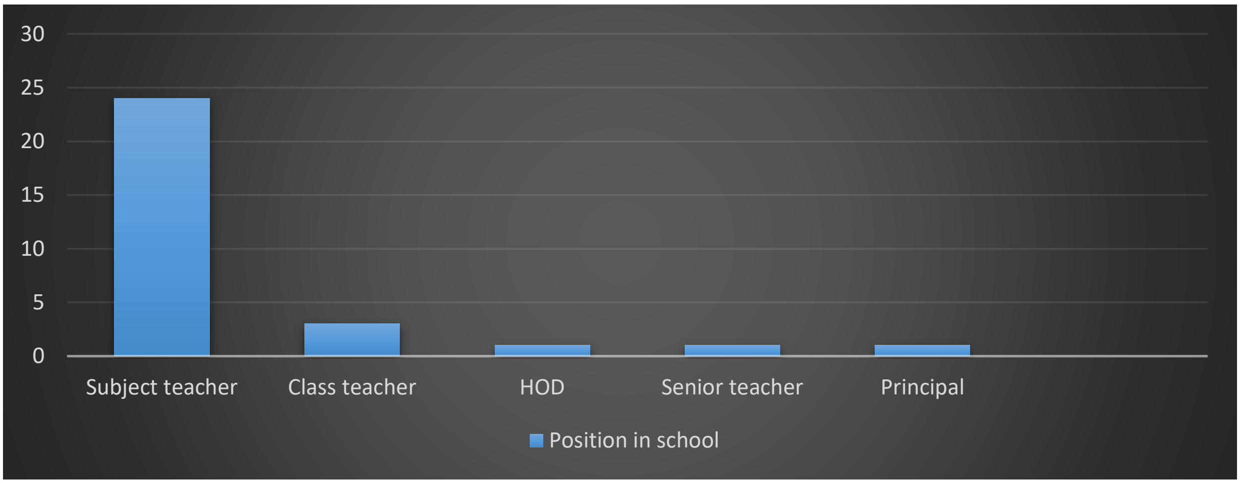


Figure 4-3: Respondents' position in school

Evidence from StatsSa (2013) shows that the majority of educators (69,1%) in the selected South African rural district had more than 11 years teaching experience. The respondents' teaching experience was distributed as 13.3%, 10%, 13.3% and 10% for 0-2 years, 3-5 years, 6-8 years and 9-11 years respectively. The remaining 53.3% of the respondents had over 11 years teaching experience. Given these data, it can be inferred that the educators in the sample are relatively mature. This is supported by the distribution of the respondents' ages which were 5 (16.7%), 4 (13.3%), 16 (53.3%) and 5 (16.7%) for below 30, 30-39, 40-49 and 50 and above respectively. The majority of the teaching staff (70%) were above the age of 40 as shown in Figure 4.1d. With regard to the educators'experience in teaching Natural sciences, the distribution was 4 (13.3%), 9 (30%), 10 (33.3%) and 7 (23.3%) for less than a year, 1-5 years, 6-10 years and 11 years and over respectively.This denotes that despite the relative maturity and work experience of the educators, their experience in teaching natural sciences was low.

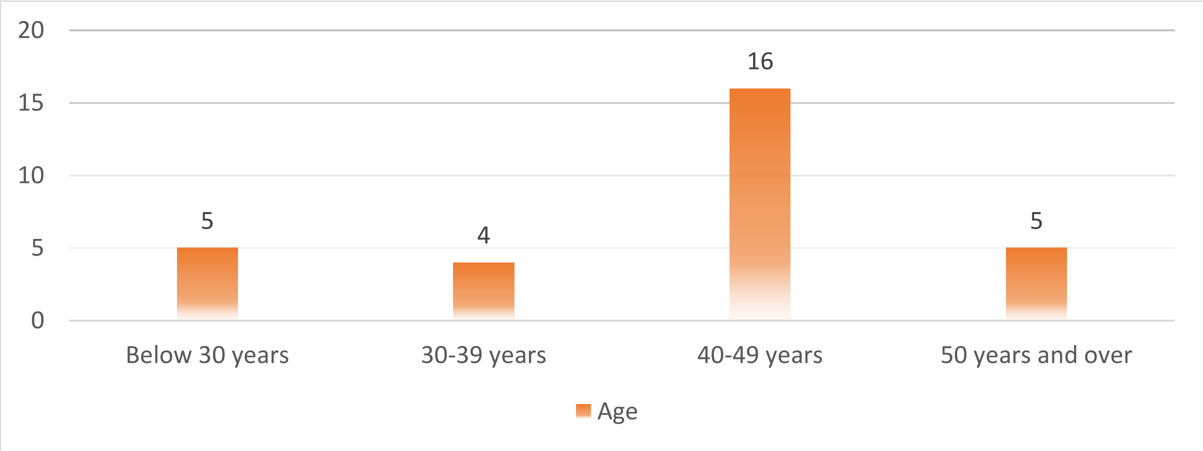


Figure 4-4: Age distribution of respondents

Summary of findings from biographic data and chi square correlations (Appendix G)

The gender variable and the highest qualification attained by the educators had a statistically significant correlation coefficient at 10%. The correlation coefficient was positive indicating that female respondents had slightly higher qualifications compared to their male counterparts. The gender variable was not significantly correlated to any other variable selected. Age was significantly correlated with experience in teaching natural sciences at the narrow 1% significance level. The correlation was positive and expected, as on average, work experience ought to have been positively correlated with age. Nonetheless, teaching experience variable was not significantly correlated to any other. Age was also significantly correlated with the choice of science inquiry and case study variables at 5% significance. This was an indication that mature educators were less likely to select these techniques. The educators' highest qualifications were only significantly correlated to gender but no other selected variable.

4.2 Results on strategies educators use to teach natural science curriculum

This section presents data on strategies used by educators to teach natural science. The aim of this part is to understand the strategies that the educators know and also employ in order to enhance the teaching and learning of natural science.The questions sought to capture educators' perspectives towards the usefulness and effectiveness of a variety of teaching methods. The respondents indicated their agreement or disagreement as to whether the provided teaching methods were effective for natural sciences learning.

4.2.1 Quantitative results on strategies used by science educators

Table 4-2: Quantitative results on strategies used by educators to teach natural science

Strategies	Responses	Frequency	%
Demonstration	agree	26	86.7
	neutral	2	6.7
	no response	2	6.7
	Total	**30**	**100.0**
Problem solving	agree	27	90.0
	neutral	2	6.7
	no response	1	3.3
	Total	**30**	**100.0**
Simulation	agree	7	23.3
	neutral	12	40.0
	disagree	5	16.7
	no response	6	20.0
	Total	**30**	**100.0**
Inquiry	agree	8	26.7
	neutral	13	43.3
	disagree	5	16.7
	no response	4	13.3

	Total	**30**	**100.0**
Case study	agree	23	76.7
	neutral	5	16.7
	no response	2	6.7
	Total	**30**	**100.0**
Lecture	agree	17	56.7
	neutral	4	13.3
	disagree	6	20.0
	no response	3	10.0
	Total	**30**	**100.0**
Discussion	agree	28	93.3
	no response	2	6.7
	Total	**30**	**100.0**
Brainstorming	agree	23	76.7
	neutral	4	13.3
	no response	3	10.0
	Total	**30**	**100.0**
Modelling	agree	14	46.7
	neutral	12	40.0
	disagree	2	6.7
	no response	2	6.7
	Total	**30**	**100.0**
Role-play	agree	19	63.3
	neutral	4	13.3
	disagree	3	10.0
	no response	4	13.3
	Total	**30**	**100.0**

Question and answer	agree	26	86.7
	neutral	2	6.7
	no response	2	6.7
	Total	**30**	**100.0**
Presentation	agree	28	93.3
	no response	2	6.7
	Total	**30**	**100.0**
Project	agree	28	93.3
	neutral	1	3.3
	no response	1	3.3
	Total	**30**	**100.0**
Investigation	agree	29	96.7
	no response	1	3.3
	Total	**30**	**100.0**

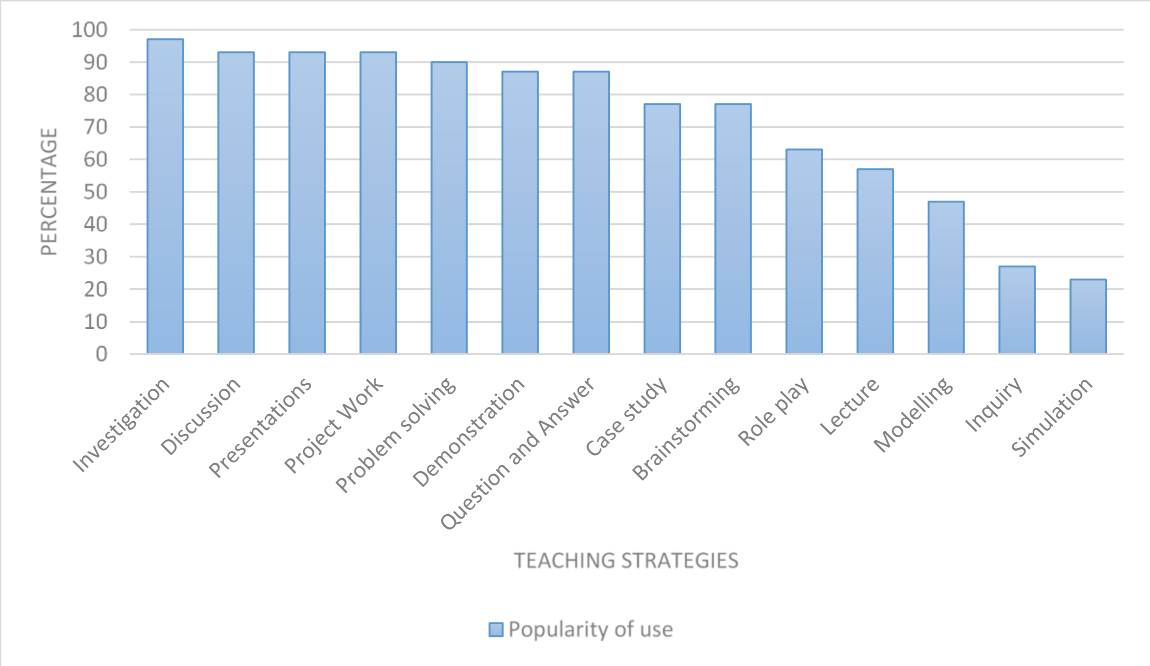


Figure 4-5: Bar graph on teaching methods

4.2.2 The strategies most used by educators to teach natural science curriculum

Data illustrates that the strategies most used by educators, in the descending order of use were: Investigation (97%); each among Discussion, Presentation and Project (93%); Problem solving (90%); each among Demonstration and Question and Answer (87%); each among Case study and Brainstorming (77%); Role-play (63%); Lecture (57%); Modelling 47%, Inquiry 27% and Simulation 23%.

Aji and Budiyono (2018) list the different categories that encourage SL approach and also promote active engagement and problem solving skills as expository learning strategy (lecture method), contextual teaching and learning (Demonstrations), Inquiry learning strategy (Discussions) and problem based learning strategy (investigations and problem solving). Table 4.2 illustrates instructional strategies and the observation by Akdeniz (2016) that macro and micro strategies exist. Under macro strategies, there is reference to metacognition and active student. The data shows active involvement of students in the learning.

Akdeniz (2016) mentions that macro strategy is a focus strategy that contains learner focus and instructor focus. The strategy allows relationship between students' background knowledge and what they have just learnt, and also encourages students to ask questions and state their views. There are proposed activities mentioned under macro strategy, for instance, in discussions and brainstorming, two of which are forming student discussion groups regarding the instructional context and encouraging students to share their thoughts in order to help them reach broader concepts and generalizations. Micro strategies are also referred to as process strategies. Participants mention projects, investigation and presentations. Akdeniz (2016) states that the process strategies reveal how the instruction is implemented. Futhermore, the following skills are developed when using micro startegies: explain, solve, show, think, transfer, comment and make a statement. The present researcher is of the opinion that these strategies mentioned by participants in the study are good in that they promote active and higher order thinking as well as science and SL. In addition, the skills that are promoted by microstrategies can assist educators when compiling their tasks for assessments.

4.2.3 The strategies least used used by educators to teach natural science curriculum

Data shows that the strategies least used by educators were Modelling (47%), Inquiry (27%), and Simulation (23%). The present researcher assumes that educators encounter challenges in these strategies or they are not familiar with them. In the qualitative inquiry strategy, findings reveal that some educators know a few aspects, while others struggle with many aspects of inquiry. Simsek (2011) mentions that instruction requires not only systematic guidance for learning but also a purposeful organization of experiences to help students achieve the desired change in their performances. These strategies according to the literature are macro strategies (Akdeniz, 2016). They are active engagement strategies to enhance teaching and learning of science.

4.3 Qualitative results on strategies used by educators to teach natural sciences curriculum

The main themes that emerged were as follows: strategies used by educators, strengths and weaknesses, educator support, relevant strategies in enhancing science learning and SL and lastly, assessment.

Table 4-3: Themes and sub-themes on strategies used by educators to teach natural

Themes	Sub-themes	Related issues
Educators strategies	Strategies employed by educators	Variety of different methods were used. Challenges experienced in some methods
	Promotion of constructivist approach	Promote interactive approach in class. Encourage learners to participate. Challenges are experienced
	Benefits of incorporating educators' strategies	Hands on promoted Construct knowledge or information on their own Encourage research and create confidence amongst learners. Promote thinking skills

4.3.1 Strategies employed by educators

Although most educators mentioned the strategies which they knew and which they employed in classrooms, there were some educators with other opinions concerning the strategies. For example, some educators responded as follows:

> *I used some strategies like discussion, demonstration and problem solving but mostly I use lecture method because I do not have resources and text books Teacher (T1).*

> *I know and use the following strategies discussion, textbook method, information and communication technology (T3).*

> *Lecture method, discussion, problem solving, investigation and presentation I use them in my class (T5).*

FGs also shared their experiences on how they were taught science in the class and therefore the possibility of linking learners' responses with those of educators emerged. For example, FG1 stated:

> *Our teacher introduce the lesson by giving us the notes, explain them and ask questions and sometimes we work as groups . We do not work as groups, we work individually (FG1) and (FG7).*

Educators from two schools revealed that they used different strategies depending on the topic they taught. One teacher said:

> *Lecture method is not good, we are not supposed to use it. We employ it because sometimes learners know nothing and the teacher contribute by telling them (T8).*

FG8 and FG10 concurred by highlighting that their teacher would start a lesson by asking questions from the previous lesson and then come to the topic. One learner from the group responded by saying: We do work as groups when we are given a research task (FG10).

Another educator shared the view by saying :

> *Lecture method is an easy way of relaying information. I prepare thouroughly and present it. However, I think it is not good for the young ones i.e grade 9 learners. It must be used once in a while (T10).*

The statement indicated above is confirmed by most learners as they stated that they listened to the educator and wrote notes. Another FG mentioned that:

> *Our teacher asks questions from previous topic and teach the new one (FG2). Concerning the theme on strategies employed by educators, the majority responded with discussion method, lecture method, problem solving method and group work method.*

4.3.2 Promotion of constructivist approach

Concerning strategies that promote interactiveness in the classroom, educators generally came up with similar understanding but a minority had different opinions. Constructivism happens when learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Vygotsky,1985). Educators believed that the strategies they used promoted constructivist approach. One educator said:

> *For the promotion of constructivist, I use presentations because learners do the task on their own. They expect that questions will be asked either by the teacher or other group members in the audience so they must be ready. Therefore, the interactiveness is promoted (T2). We do not work as groups yet, and we never participated in presentations we answer questions individually or write classworks. (FG2).*

Some of the educators highlighted that strategies like group work promoted interactive approach in the class e.g., if you give learners case studies to solve, they are able to construct their own knowledge without the educator's assistance. One educator articulated that*:*

> *Constructivist approach is promoted to some extent e.g., when I use discussion strategy, learners become passive because of the language barrier. If I ask in vernacular they participate and it is a challenge since exams are done in english (T10).*

Other educator comments were*:*

> *Demonstration and investigations involve the learners, they have what we call imaginery. You demonstrate what they are able to see, thereafter you will have follow up questions and they will interact (T5); I use the following strategies to promote interactive learning: demonstrations, group work and Investigations (T8).*

The processes in use which promoted constructivism were investigations, presentations, question and answer and demonstrations.Responses from some FGs linked with what the educators said, although some learners stated that they never participated in strategies like group work and presentations. It shows that in general, many educators try to promote constructivism in their classes.

4.3.3 Educators' responses on the benefits of strategies

Educators responded differently on the issue of benefits they received when using these different strategies. Mostly they responded positively, for instance:

> *Combining these strategies, they promote investigating skills and they motivate learners to look for more information on their own. By doing that the information will be kept for a very long time in their memories, since they are the ones conducting the research (T2).*

> *Many educators shared their experiences: Natural Science is not like history where you learn about what happened. Science is a practical subject, what they can see learners can remember for a very long time (T4) Furthermore, Learners are able to work alone (T4). Encourage research and create confidence amongst learners (T8). Benefits are : promote thinking, makes the lesson interactive and interesting (T9).*

Educators indicated that some of the strategies made learners to be more responsible.

> *Learners are able to construct knowledge on their own (T6)*. Our teacher involve us in a lesson and we work as groups and discuss about the topic (FG6).

The present researcher is of the view that the responses given by educators show that by using the different strategies they benefit because teaching and learning is enhanced. Many responses show that, combined strategies promote investigating skills and hands-on experiences, encourage research and create learner confidence. Practical activities help to recall information effectively.

4.3.4 Main findings on strategies used by educators to teach natural science curriculum

Major findings are presented below in table 4.4 which presents a summary of both quantitative and qualitative findings on strategies used by educators to teach natural science curriculum, showing similarities and contrasts.

Table 4-4: Summary of findings from quantitative and qualitative data

Findings (Quantitative data)	Findings (Qualitative data)
The strategies identified by the educators had slight variations in their use across the various respondents. The problem solving and discussions approaches were relatively more consistent methods at 90% and 93.3% approval rates. The lecture method had the least use approvals in this group with an outcome of 56.7%.	Educators confirmed the strategies they employed in class :Discussion method, lecture method,problem solving and Demonstration method. They also mentioned that there were challenges experienced in the use of these startegies.
The key methods utilised by educators showed approval rates which were high indicating a general concensus on teaching methods. The methods had usage rates of 86.7%, 93.3% and 96.7% for demonstrations, discussions and investigations respectively.	key findings that promote constructivism according to educators: Investigations, question and answer and demonstrations. Acknowledged that the approach encouraged learners to participate. Confirmed that language barrier is a challenge.
Methods which promote learner activity and thinking skills were relatively popular but not all had high usage rates for various reasons. Project work was the most common with a rate of 93.3%. Brainstorming and case studies which encourage deep thought and realistic approaches were at 76.7%. Simulations, though, had a very low usage rate at 23.3%.	Educators mentioned the benefits of incorporating the strategies in the N.S teaching as: Promoting hands-on Able to construct knowledge. Develop research skills and create confidence. Promote thinking skills. Group work is promoted.

4.3.5 Interpreting the summary of the findings

The Table above shows that there is a strong link between the quantitative and qualitative outcomes. With the exclusion of the simulations method, the respondents showed consistency in identifying the methods which educators utilised to deliver science content and SL. The key findings revealed that: discussion, lecture, investigation, problem solving, demonstration and presentation were employed by science educators in their classrooms; the strategies that promoted constructivism were investigations, presentations, question and answer, demonstrations and projects. Concerning the benefits of incorporating the strategies in science teaching, educators concurred that the strategies promoted hands-on activities and students were able to construct knowledge, develop research skills, create confidence, promote thinking skills and do group work.

4.3.6 Correlation Analysis of teaching methods

The Table 4.5 below shows the chi-square correlations among selected educators' biographical and employment variables and teaching strategies. The correlations among the variables indicate the degree of linear association among them. The correlation tests are measures of movement in one along a linear scale rather than tests for causality. The significance level of the correlations was tested at 1%, 5% and 10% indicated as (***; ** and *), respectively.

Table 4-5: Correlation analysis of teaching methods

		GEN	AGE	H/Q	EXPNS	DEM	P/S	SIM	INQ	C/S	LECT	DISC	BRAIN	MOD	RP	Q/A	PRES	PRO	INVEST
GEN	χ^2	1	.122	.307	.251	-.250	.195	-.139	-.173	-.254	-.091	.018	-.089	.022	-.168	.015	-.250	-.172	-.174
	Sig.		.519	.099*	.182	.183	.302	.465	.360	.175	.634	.925	.640	.907	.374	.936	.183	.364	.359
AGE	χ^2		1	-.265	.718***	-.112	.067	-.252	-.428**	-.387**	-.286	.102	-.054	-.117	-.214	-.174	-.110	-.223	-.224
	Sig.			.157	.000	.557	.726	.179	.018	.034	.126	.591	.778	.540	.256	.357	.562	.237	.233
H/Q	χ^2			1	-.130	.178	-.143	-.068	-.115	-.078	-.140	.051	.068	-.074	-.016	-.205	.179	.040	.036
	Sig.				.492	.346	.450	.721	.545	.682	.462	.788	.721	.697	.933	.276	.344	.836	.852
EXPNS	χ^2				1	.091	.059	-.082	-.263	-.189	-.121	.228	.107	-.050	.027	-.049	.091	-.124	-.127
	Sig.					.633	.757	.666	.160	.318	.524	.226	.573	.795	.889	.798	.632	.514	.505
DEMON	χ^2					1	-.051	.533***	.288	.463**	.362**	.464***	.801***	.461**	.681***	-.073	1.000***	.694***	.695***
	Sig.						.788	.002	.123	.010	.049	.010	.000	.010	.000	.701	.000	.000	.000
P/S	χ^2						1	.374**	.478***	-.052	.556***	.694***	.556***	.694***	.472***	.694***	-.051	-.036	-.035
	Sig.							.042	.008	.785	.001	.000	.001	.000	.008	.000	.790	.852	.853

SIM	χ^2							1	.782***	.535***	.673***	.534***	.668***	.533***	.787***	.533***	.534***	.370**	.371**
	Sig.								.000	.002	.000	.002	.000	.002	.000	.002	.002	.044	.043
INQ	χ^2								1	.684***	.854***	.289	.526***	.685***	.716***	.681***	.289	.473***	.473***
	Sig.									.000	.000	.122	.003	.000	.000	.000	.122	.008	.008
C/S	χ^2									1	.801***	-.073	.354*	.460**	.680***	.463**	.463***	.694***	.695***
	Sig.										.000	.700	.055	.011	.000	.010	.010	.000	.000
LEC	χ^2										1	.363**	.634***	.799***	.854***	.801***	.363**	.556***	.557***
	Sig.											.049	.000	.000	.000	.000	.049	.001	.001
DISC	χ^2											1	.802***	.461**	.681***	.464***	.464***	-.050	-.050
	Sig.												.000	.010	.000	.010	.010	.792	.795
BRAIN	χ^2												1	.799***	.849***	.355*	.802***	.557***	.557***
	Sig.													.000	.000	.054	.000	.001	.001
MOD	χ^2													1	.677***	.461**	.461**	.694***	.695***
	Sig.														.000	.010	.010	.000	.000
R/P	χ^2														1	.681***	.681***	.473***	.473***
	Sig.															.000	.000	.008	.008
Q/A	χ^2															1	-.072	-.051	-.050
	Sig.																.705	.790	.792
PRES	χ^2																1	.695***	.695***
	Sig.																	.000	.000
PROJ	χ^2																	1	1.000***

	Sig.																		.000

Key: GEN (Gender); AGE (Age); H/Q (Highest qualification); EXPNS (Experience); DEM (Demonstration); P/S (Problem solving); SIM (Simulation); INQ (Inquiry); C/S (Case study); LECT (Lecture); DISC (Discussion); BRAIN (Brainstorming); MOD (Modelling); RP (Role-play); Q/A (Question and answer); PRES (Presentations); PRO (Project work); INVEST (Investigations).

The correlation description presented in Table 4.5 and Figure 4.2 explains that gender variable and the highest qualification attained by the educators had a statistically significant correlation coefficient at 10%. The correlation coefficient was positive indicating that female respondents had slightly higher qualifications compared to their male counterparts. The gender variable was not significantly correlated to any other variable selected. Age was significantly correlated with experience in teaching natural sciences at the narrow 1% significance level. The correlation was positive and expected as on average, work experience would be positively correlated with age. The teaching experience variable was not significantly correlated to any other. Age was also significantly correlated with the choice of science inquiry and case study variables at 5% significance. This was an indication that mature educators were less likely to select these techniques. The educators' highest qualifications were only significantly correlated to gender and no other selected variable.

The demonstration method is positively correlated to most of the given teaching methods except inquiry and question and answer. The correlations are significant at 1% except for case study, lecture and modelling which are at 5%. Of particular interest is the direct unit correlation between demonstrations and presentations. Likewise, problem solving is significantly correlated to most variables with the exclusion of case study, presentations, project work and investigations. The simulation method is correlated significantly to all the teaching methods. The inquiry method was also significantly correlated to the majority of the other teaching methods except discussions and presentations. Case study is significantly correlated to most variables. The only variable with which no significant correlation exists is discussions. The lecturing method is positively correlated with all the teaching methods. The discussion method is also significantly correlated to the majority of the teaching methods except inquiry, case study, projects and investigations.

The discussions, brainstorming, modelling and role-playing methods are significantly correlated among one another and with all other teaching methods. The question and answer method has statistically significant correlation with most of the teaching methods except demonstrations, presentations, project work and investigations. Likewise, presentations are significantly correlated with most variables except problem solving and inquiry. Project work is not significantly correlated with problem solving, discussions and question and answer methods only. The relationships in project work are also identical for the investigation method.

4.4 Results on the strengths and weaknesses of the strategies

The responses from the educators show that there were advantages and disadvantages when using the strategies. Some strategies incorporated interactive learning.

4.4.1 Quantitative results on strengths and weaknesses of these strategies in promoting science and SL among learners

Table 4-6: Quantitative results on strengths and weaknesses of demonstration

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Demonstration	Generates interest in learners and encourages active participation and psychomotor activity	19	32	Can be time consuming during preparation and practice	11	41
	Learners can practically show their understanding	13	22	Can be inefficient and ineffective in large classes	9	33
	Learners can cooperate during the learning process that promotes collaborative learning	11	18	Focuses learners' attention on psychomotor activities and discourages higher order thinking/Limited to skills and/or practical subjects	7	26
	Both simple and complex tasks can be easily grasped for permanent learning	9	15			
	Teacher can coordinate learning in the preferred manner.	8	13			

Table 4.6 presents educators' comments on the strengths and weaknesses of demonstration strategy. Educators identified 60 strengths. These in descending order of number of responses were: generating interest and psychomotor activity among learners (19; 32%); learners can show their practical understanding (13; 22%); encourages collaborative learning (11; 18%); Simple and complex tasks can be grasped/permanent learning (9; 15%); teacher can coordinate learning in their preferred subjects (8; 13%).

There were 27 educators who identified several weaknesses of the demonstration strategy. The most common response was the time consuming aspect associated with preparation and practice of demonstration (11; 41%). The succeeding weaknesses of the demonstration method were that it was regarded as inefficient and ineffective in large classes (9; 33%), focused learners' attention on psychomotor activities and discouraged higher order thinking/limited to skills and/or practical subjects (7; 26%).

- **Discussion**
    - **Strengths**
    - **Demonstration**

Demonstration generates interest in learners besides encouraging active participation and psychomotor activity. Achimugu (2018) reveals that demonstration involves students by displaying and doing activities to enhance interest in the classroom. Daluba (2013) is in agreement with Achimugu (2018) who emphasizes that demonstration gives a real life situation and motivates students by showing the correct steps of doing things. Literature stresses that demonstration strategy needs to be embraced for the reason that it arouses students' curiosity, attention and interest and promotes their performance in learning (Daluba, 2013). In supporting Daluba (2013) Achimugu (2018) explains that demonstration puts the learner at the centre of learning and the educator as a facilitator. It shows that when a student is engaged in practical activity, understanding is likely to occur. Therefore, it is clear that demonstration practised by educators promotes active engagement in class and that is relevant for science learning and promoting science literacy. The strategy encourages students to carry out the demonstration themselves so that they grasp information easily. The educator guarantees full active participation through questioning, brainstorming and debates during the lesson (Achimugu, 2018). Moreover, Mundi (2006) explains that demonstration is a powerful motivator in lesson delivery and students receive responses through their own products. It clearly shows that whether the concept is simple or difficult, through the use of demonstration skills students' retention of information is enhanced. Literature highlights that demonstration promotes translation of theory into practice (Gwarinda, 1993). Achimugu (2018) explains that demonstration puts the learner at the centre of learning.

- Weaknesses

Educators said that demonstration could be time consuming. This implies that educators should technically strategize when to use demonstration. Educators also mentioned that the strategy could be inefficient and ineffective in large classes as it might not be easy to control the class. Dividing students into groups, may help to some extent. Educators also acknowledged that the strategy focused learners' attention on psychomotor activities, discouraged higher order thinking and was limited to skills and practical activities.

Table 4-7: Quantitative results on strengths and weaknesses of problem solving

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Problem solving	Encourages cooperative learning and communication	10	21	Time consuming especially during the exercise and assessment	13	45
	Skills can be transferable to real world situations	15	32	May be irrelevant in some instances	4	14
	Encourages learner participation and deep thinking	5	11	May not be applicable for standard tests and exams	7	24
	Can be applied to a diverse group of learners	6	13	Can be extremely difficult for some learners	5	17
	Promotes long term learning and retention of information	11	23			

The problem solving approach to teaching or problem-based learning method generated 47 responses from the educators. Five key strengths were identified- the most common being that it created transferrable skills to real world situations (15; 32%). The next lower common response was on promoting long term learning and retention of knowledge (11; 23%). The other strengths in descending order were encouraging cooperative learning and fostering communication among learners (10; 21%); applicability to a diverse group of learners (6; 13%) and encouragement of learner participation and deep thinking (5; 11%).

On weaknesses of the problem solving method, time consumption during the practical exercises and assessments was identified by the respondents (13; 45%). This was the most commonly provided disadvantage. Lower responses were on inapplicability for standardised tests and examinations (7; 24%); extreme difficulty for some learners (5; 17%) and irrelevance in some instances (4; 14%).

- **Discussion**
    - **Strengths**

Problem solving strategy is the most identified strategy by the science educators since it involves transferrable skills like research skills, communication skills and debating skills which promote constructivism in the classroom. The participants stated that problem solving encouraged cooperative learning and communication. Literature highlights that when solving a problem five stages need to be followed and these are (a) student orientation to the problem; organising students to learn; guiding individuals and group investigations; developing; presenting work ; analysing and lastly evaluating the problem solving process (Aji and Budiyono, 2018). The present researcher agrees with the author that problem solving promotes group investigation whereby students work co-operatively to solve a problem. Mokiwa and Msila (2013) mention the importance of language when teaching science as it promotes educational quality. With regard to encouraging learner participation and deep thinking, it is emphasized that students must be encouraged to collect suitable information and conduct experiments to get clarity about the problem (Aji & Budiyono, 2018).

- **Weaknesses**

The study found that the problem solving strategy is time consuming especially during the exercise and assessment. The strategy needs a lot of time, it cannot be used for exams and is best suitable for other tasks like assignments, projects etc. Problem solving can be extremely difficult for some learners. Students who are weak in experiments have to search for information and experience challenges (Grant, 2002; Kurzel & Rath, 2007).

Table 4-8: Quantitative results on strengths and weaknesses of simulation

Strategy	Strengths	N°	%	Weaknesses	N°	%
Simulations	Provides practice of real world exercises	12	30	Can be difficult to organise and manage	1	3
	Improves confidence of the learners	6	15	May be impractical for large classes	11	31
	Allows for practical feedback on the exercise	4	10	Requires strict attention/monitoring by the teacher or assessor	9	26
	Provides safe method for otherwise risk practical activities	9	23	Some require resources which are unavailable to rural schools	14	40
	Links theory with practice	9	23			

There were 40 responses on the strengths of the simulation method. The most commonly identified advantage of using simulations was that they provided practice for real world scenarios (12; 30%). Some of the respondents (9; 23%) observed that simulations provided safe methods for otherwise risky practical activities. The number and percentages for other responses were: linking theory and practice (9; 23%); improving confidence of the learners (6; 15%), and provision for practical feedback on the exercises (4; 10%).

There were 35 responses on the weaknesses of the simulation method. The majority of the responses were centralised around two main disadvantages: simulations may require resources which are often unavailable in rural schools (14; 40%) and practical challenges in large classes (11; 31%). Other responses were: simulations require strict attention and monitoring by the educators and assessors (9; 26%) and difficulty to organise and manage simulations(1; 3%).

- **Discussion**
  - **Strengths**

Improvement of learner confidence was mentioned by the educators. Simulation prepares learners to deal with unanticipated events, which in turn increases their confidence in real-world work performance (Lateef, 2010). Simulation promotes different skills, provides students with an experimental way of learning and creates opportunities for them to gain more knowledge especially in a real-world context (Hughes & Scholtz (2015). In addition learners can learn very successful concepts by indulging themselves in simulation (Zulfiqar et al. 2018).

Regarding the observation that the strategy provides safe method for otherwise risky practical activities, literature highlights that the simulation system offers students information-rich environment where they work together, share their ideas and make a decision in certain circumstances while working in the risk-free but practical environment (Zulfiqar et al. 2018). Literature notes that, simulation system has some set of rules which students need to follow and that gives them a sense of working in the real-based scenario but risk-free (Leemkuil, Jong, & Ootes, 2000). Linking theory with practice is definitely perfect for simulation in science.

- **Weaknesses**

The two weaknesses identified were difficulty to organise and manage and practical difficulty to implement in large classes. Educators also mentioned that simulations need monitoring by the educator or assessor. Educators' poor teaching practices may have a negative effect in the simulation process, (Billingsley & Scheuermann, 2014; McPherson, Tyler-Wood, Mcenturff, & Peak, 2011). Girod and Girod (2008) observe that educators need an ever-growing set of knowledge, skills and attitudes to meet their accountabilities.

Table 4-9: Quantitative results on strengths and weaknesses of case study

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Case study	Simplifies otherwise complex activities/scenarios	13	30	Consumes relatively more time compared to other methods	15	56
	Exposes learners to real life scenarios	9	21	Little in-depth learning is achieved	3	11
	Fosters critical and analytical thinking and enhances communication	7	16	May require specific skills on the part of the teacher	1	4
	Allows for discussions and cooperative learning	5	11	May be difficult to implement if learners are disinterested.	8	30
	Promotes research skills/integrates and synthesises basic knowledge in real life cases	10	23			

Educators identified 44 responses on the strengths of the case study method. They were in descending order: simplifying otherwise complex activities/scenarios (13; 30%); promoting research skills/integrating and synthesising basic knowledge in real life cases (10; 23%); exposing learners to real life scenarios (9; 21%); fostering critical thinking and enhancing communication (7; 16%) and allowing discussions and cooperative learning (5; 11%).

The drawbacks of the case method amassed 27 responses with the most common identified being that the method was relatively more time consuming compared to other teaching strategies (15; 56%). The second lower most common disadvantage identified was that case studies were difficult to utilise if learners were disinterested (8; 30%). The less common disadvantages were stated as promoting little in-depth learning and requiring specific skills on the part of the teacher (3; 11%) and learners (1; 4%) respectively.

- **Discussion**
  - **Strengths**

Case study as a strategy that simplifies otherwise complex activities and scenarios was amongst the strengths identified by educators. Cakmak et al. (2017) caution that the language used should not be too complex so that students are able to know the scenario and understand what they are reading. On exposing learners to real life scenarios, Keller (2016) states that case study is the best method to use in the classroom as it prepares students for post secondary achievement. Sunbul, (2010) indicates that the case study method assists students to find effective solutions to problems which they encounter in similar real life situations in a shorter time. Some of the benefits identified by educators were on fostering critical and analytical thinking, enhancing communication, contributing positively to the development of critical thinking, problem solving and decision making skills. Previous studies (Bilen, 2006; Nas, 2006 and Gozutok, 2011) report that critical thinking is developed when students are engaged in the case discussions which promote communication. Moreover, for discussions and cooperative learning, students have the opportunity to learn by discussing, therefore, they enjoy the method (Kucukahmet, 2009). Team work is very important whereby cooperative learning is the key for this method as students work in groups to find solutions. Cakmak (2017) states that cases can be examined with the participation of the whole class or working in small groups.

Promotion of research skills as well as integration and synthesis of basic knowledge in real life cases are other strengths mentioned by respondents. Demirel (2009) mentioned that another method similar to the case study method is the research case study. In this method, a case is explained to the participants, data is collected, possible solution or strategies for the decision are identified and finally decisions are made to come up with the solutions.

- **Weaknesses**

Weaknesses mentioned by respondents included consumption of relatively more time compared to other methods. Literature too highlights that preparing case studies takes a long time and can be difficult to implement in congested classrooms (Alacapinar, 2008; Kucukahmet, 2009 & Sunbul, 2010). Another weakness mentioned was that little in-depth learning was achieved and that specific skills on the part of the educator might be needed. Other studies have also shown that case studies require educators to make good preparations before application (Alacapinar, 2008; Kucukahmet, 2009 & Sunbul, 2010). Regarding the difficulty to implement, if learners are disinterested due to the need for deep and critical thinking to solve the problem, other researchers too have faced similar challenges. For example, Sunbul (2010) reports that sometimes due to different challenges it may be difficult to implement the method.

Table 4-10: Quantitative results on strengths and weaknesses of lecture

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Lecture	Teacher maintains easy control of class and content	8	19	Promotes memorisation by learners/Little in-depth learning and/or higher order thinking is achieved	10	24
	Easier to achieve set objectives of the teacher	3	7	Limited learner participation in the learning process	13	31
	Useful and effective for large classes	10	23	Assessment of learner understanding and feedback is limited during the class	6	14
	Easy, time and cost effective to implement	18	42	Requires effective speaking skills from the teacher	5	12
	Can relate large volumes of information within a single session	4	9	Promotes "chalk and talk" approach	8	19

The lecture method recorded 43 responses on strengths. Of these, the method was identified by the majority of educators as being easy and time and cost effective (18; 42%). The second most common response was its usefulness and effectiveness for large classes (10; 23%). The following advantages were identified: teacher maintains easy control of the class and content (8; 19%); can relate large volumes of information in a single session (4; 9%) and easier to achieve objectives set by the teacher (3; 7%).

There were also 42 responses on weaknesses. The lecture method's most noted weakness was that it promoted limited learner participation in the learning process (13; 31%). This was followed by lower percentage responses: promotion of memorisation by learners/little in-depth learning and/or higher order thinking (10; 24%); promotes the "chalk and talk" approach to teaching (8; 19%); assessment of learner understanding and feedback is limited (6; 14%) and requiring effective speaking skills from the teacher (5; 12%).

- **Discussion**
    - **Strengths**

The method is also known as the chalk and talk and the educator verbally presents ideas, concepts and facts to learners (Anaekwe et al. 2010). On educator maintaining easy control of class and content as a strength, McKeachie (1997) aver that students prefer the lecture approach because it arranges the subject matter for them, and prepares them well for tests. Marmah (2014), concurs by stating that students prefer lecture method as the best teaching method because educators provide all the knowledge related to the topic and it is a time saving method. Furthermore, it is easier to achieve set objectives of the educator and also easy to achieve the goals (Marmah, 2014). The findings of this study established that lecture strategy is not only easy, but also time and cost-effective to implement. Recent studies indicate that, when applying lecture method it is possible to educate a large number of students at once, thereby lowering costs (Marmah, 2014). Achimugu (2018) also observes that the lecture method is the cheapest technique to use when implementing the course outline in class. Literature views lecturing method as an oral clarification of learning the material to a group of listeners to achieve certain learning objectives in a relatively large number (Aji & Budiyono, 2018).

- **Weaknesses**

Participants mentioned weaknesses of lecture as promoting memorisation by learners/little in-depth learning and/or no higher order thinking is achieved. Literature confirms that the lecture strategy may not be good to promote higher order thinking skills, since students are always listening (Moore, 2009). It is emphasized that students tend to forget information immediately after the lesson is taught (Marmah, 2014). It is possible as the strategy is not engaging students in the lesson, then they become bored and forget the information.

Other weaknesses mentioned were, limited learner participation in the learning process, poor assessment of learner understanding and low feedback during the class. Literature points out that the lecture method cannot teach motor skills, application, analysis, synthesis or evaluation and does not influence attitudes and values, (Jarvis 2006). In line with the above, Achimugu (2018) confirms that lecture does not encourage the acquisition of critical thinking skills and students' active participation in the lessons.

Another response on weaknesses was the need for effective speaking skills from the educator. The educator must have good communication skills that will attract learners to listen with understanding. Promotion of “chalk and talk” approach was another weakness identified. Anaekwe, et al. (2010) explain that lecture is known as chalk and talk method and also as a process of delivering verbally a body of knowledge according to pre-planned scheme. Furthermore, it is a one way strategy that focuses on telling and listening technique (Aji & Budiyono, 2018).

Table 4-11: Quantitative results on strengths and weaknesses of discussion

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Discussion	Encourages learner participation	15	29	Only applicable when learners have some knowledge of the content	6	
	Collaborative learning improves interpersonal relationships among learners	8	15	Some learners may be dominant while others are reluctant	10	37
	Learners improve each other’s content and understanding and promotes constructivist approach.	14	27	Can be difficult to implement and control in large classes	11	41
	Relatively more interesting/enjoyable learning method for learners	4	8			
	Promotes logical thinking, critical analysis and evaluation	11	21			

For the discussion method, there were 52 positive responses. The most common response was that the method encourages learner participation (15; 29%). In descending order of percentages, other responses were: learners improve each other’s content and understanding and promotes constructivist approach (14; 27%); promotes logical thinking, critical analysis and evaluation (11; 21%); enhances collaborative learning and improves interpersonal relationships among learners (8; 15%) and relatively more interesting/enjoyable learning method for learners (4; 8%).

Relatively fewer (27) responses were given on the weaknesses of the discussion strategy. Of these, the majority focused on discussions being difficult to implement and control in large classes (11; 41%) with some learners being dominant while others reluctant (10; 37%). The least common weakness from the educators was that discussions may only be applicable when learners have some prior knowledge of the content (6; 22%).

- **Discussion**
  - **Strengths**

It emerged from the study that learner participation was encouraged. Learners were engaged in discussion in the class, worked as groups and collaborated with their educator to understand the expectations of the group task. Literature too shows that discussion strategy allows a superior degree of collaboration between the learners (Chingombe, (2013). Collaborative learning was also promoted since learning as group sharpened research skills to share ideas. Learners can improve each other's content and understanding and promote constructivist approach and enjoyable learning method for learners. Literature highlights that educators need to engage learners for teaching to be successful (Aji & Budiyono, 2018). Discussion promotes logical thinking, critical analysis and evaluation and the strategy is more interesting. Chingombe (2013) states that pupils are free to make some contributions during their learning processes and their views are respected. Gatawa (1993) emphasises that educators should ensure that group work is effective during discussions session.

  - **Weaknesses**

Some of the weaknesses mentioned were that it was only applicable when learners have some knowledge of the content and that some learners may feel inadequate because they are overpowered by the fast learners. However, literature indicates that discussion strategy allows a greater degree of collaboration between the learners (Chingombe, 2013). Sometimes the strategy can be difficult to implement especially in large classes. Good monitoring will be needed if the strategy is used under those circumstances. Previous research (Bilen, 2006; Nas, 2006; Gozutok, 2011) found that critical thinking was established when students were involved. In addition, the strategy becomes successful when learners have enough information and if they use their research skills effectively.

Table 4-12: Quantitative results on strengths and weaknesses of brainstorming

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Brainstorming	Interactive way of learning/ promotes constructivism	11	20	Easily degenerates into arguments and fights	9	23
	Can generate a variety of good ideas and responses	7	13	Control is not easy to maintain for the teacher	10	26
	Stimulates and enhances creativity among learners	9	16	Maybe ineffective in some instances were learners are timid	4	
	Enhances self-learning and boosts cognitive skills	13	23	Ineffective in large classes	9	23
	Provides autonomy for learners to develop ideas and critically and extensively think about them	16	29	Some learners may dominate while others remain idle	7	18

There were 56 responses on the advantages of brainstorming strategy. The most chosen response was that brainstorming provides autonomy for learners to develop ideas and critically and extensively think about them (16; 29%). The next lower common responses were: the strategy enhances self-learning and boosts cognitive skills (13; 23%); an interactive way of learning which promotes constructivism (11; 20%); brainstorming stimulates and enhances creativity among learners (9; 16%) and generates a variety of ideas and responses (7; 13%).

There were 39 responses on weaknesses. The most common one was that during brainstorming sessions, control is not easy to maintain for the teacher (10; 26%). Following this in descending order were: a method which easily degenerates into arguments and fights, becoming ineffective in large classes (9; 23%); some learners may dominate while others remain idle (7; 18%) and maybe ineffective in some instances were learners are timid (4; 10%).

- **Discussion**
  - **Strengths**

Interactive way of learning promoting constructivism was the strength identified by participants, Tabe (2011) explains that cognitive constructivism emphasises the active role of the learner and the significance of current knowledge and understanding in mediating learning. Students are able to come up with different ideas concerning how to solve a specific problem and come up with strategies that will best suit the process (Ikwumelu & Oyibe, 2014). It clearly shows that brainstorming promotes interactive learning and problem solving.

Another strength mentioned was that brainstorming can generate a variety of good ideas and responses. Literature suggests that brainstorming integrates other forms of study such as critical thinking that is essential for logical thinking (ODE, 2014). UNC (2014) explains that brainstorming stimulates the students' background knowledge and captures their interest. Therefore, when using the strategy, students develop logical reasoning and become knowledgeable.

On stimulating and enhancing creativity among learners which was identified as a strength, AlMutairi (2015) too considers brainstorming as the best strategy which triggers creativity and solves problems in education and other fields. Students are able to learn from their and their peers' mistakes while still strengthening basic skills of brainstorming and social studies (Ikwumelu & Oyibe, 2014).

Another strength was that it enhances self-learning and boosts cognitive skills as mentioned by participants. Literature indicates that brainstorming serves as a cognitive procedure whereby a participant generates an idea and then stores it in the short-term memory (ALshammari, 2015). ODE (2014) confirms that critical thinking is enhanced though the use of different ideas.

- **Weaknesses**

Some of the weaknesses mentioned were that: brainstorming can easily degenerate into arguments and fights; members may consider their views irrelevant or no longer important, and hence, not share it after they hear another member's idea (IAAR, 2012). ALshammari (2015) observes that extroverts outperform introverts when it comes to computer-mediated groups.

Another weakness pointed out was that control was not easy to maintain for the teacher during the brainstorming session, especially with the fast learners. It needs control and monitoring from the educators. It may also be ineffective in large classes. Literature alludes that, large classes do not accommodate many teaching strategies because some learners may dominate while others remain idle. IAAR (2012) states that when large classes are not monitored it can lead to opinions that will inhibit teaching and learning.

Table 4-13: Quantitative results on strengths and weaknesses of modelling

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Modelling	Learners can develop mental views of how things work from the model	8	19	Learners may focus on the model rather than the desired concept	7	
	Caters well for some scenarios which cannot be explained well audibly	9	21	Learners with no basic knowledge may fail to understand the model	9	30
	Can clarify tasks often considered complex	10	24	May be inhibited if the teacher lacks knowledge	14	47
	Develops cognitive and meta-cognitive skills	11	26			
	Provides chance for scaffolding purposes	4	10			

On the strengths of modelling in classrooms, 42 responses were given. The most common one is that modelling develops cognitive and meta-cognitive skills among learners (11; 26%). This was followed by others: it helps clarify tasks which are often considered complex (10; 24%); caters well for some scenarios which cannot be well explained audibly (9; 21%); learners can develop mental views of how things work (8; 19%) and provides chances for scaffolding purposes (4; 10%).

On the weaknesses, 30 responses were given. These were focused on 3 disadvantages mainly. The most commonly provided weakness is that modelling can inhibit learning and teaching if the educator lacks knowledge of content and procedures (14; 47%). The other weaknesses identified were: learners with no basic knowledge may fail to understand the model (9; 30%) and learners may focus on the model rather than the desired concept (7; 23%).

- **Discussion**
  - **Strengths**

It emerged from the study that in modelling learners can develop mental views of how things work from the model. Bandura (1986) states that modelling is one of the best methods of learning any new skill or knowledge. Therefore, learners learn new skills that will help them in science learning. The strategy also uses practical activities to cater well for some scenarios which cannot be explained well audibly. Modelling plays a key role in the acquisition of fine motor skills whereby they can clarify tasks often considered complex (Abdullahi et al. 2014). Abdullahi et al. (2014) mentions that modelling plays a key role in the acquisition and progress of cognitive and meta-cognitive skills, fine motor skills, interpersonal skills and later professional skill. The strategy also provides chance for scaffolding purposes. Literature confirms that when learners develop skills on how to acquire new knowledge that means reinforcement is done through scaffolding (Bandura, 1986).

  - **Weaknesses**

Learners may focus on the model rather than the desired concept, since it involves practical work. Nonetheless, recent literature highlights that modelling plays a key role in the acquisition of fine motor skills (Abdullahi et al. 2014). Those learners with no basic knowledge may fail to understand the model and educators need to play a role in scaffolding the strategy so that no learner is left out during science learning. The strategy may be inhibited if the educator lacks knowledge, therefore educators need to be knowledgeable first. Bandura (1986) also emphasizes the scaffolding process in the modelling strategy.

Table 4-14: Quantitative results on strengths and weaknesses of role-playing

Strategy	Strengths	Nº	%	Weaknesses	Nº	%

Role-playing	Enhances long term learning and knowledge retention for participants	7	16	May be uncomfortable and/or embarrassing for some learners	8	27
	Learner-centred approach/ learner engagement	10	23	Heavily reliant on learners' ability to actively participate	7	23
	Enhances pedagogical content knowledge for both the teacher and learners	10	23	Can degenerate into chaos	10	33
	Can generate learner understanding of actual scenarios/ events	12	27	Applicable to a limited number/type of subjects	5	
	Feedback can be instantaneous	5	11			

The role-playing strategy gathered 44 responses on its strengths. Of these, the most common positive attribute of the strategy is that it fosters understanding of real life or actual scenarios (12; 27%). This was followed by equal number of responses (10; 23%) that it promotes learner-centred approach/ learner engagement and enhances pedagogical content knowledge for both the educator and learners. The two least provided advantages of the strategy were that it enhanced long term learning and knowledge retention for participants and feedback could be instantaneous with (7; 16%) and (5; 11%) respectively.

In total, 30 responses were recorded on the weaknesses of role-play as a teaching strategy. In descending order of frequency, these were: can degenerate easily into chaos (10; 33%); may be uncomfortable and/or embarrassing for some learners (8; 27%); can be heavily reliant on learners' ability to actively participate (7; 23%) and that it is applicable to a limited number/type of subjects (5; 17%).

- **Discussion**
  - **Strengths**

Educators responded that it enhanced long-term learning and knowledge retention for participants. Indeed it is true, when students engage in role-play, they are able to take the role of another person and create deeper cognitive link to the material (Hidayati et al. 2018). The strategy promotes constructivisim. Learner-centred approach/learner engagement was also mentioned by educators. Akdeniz (2016) avers that in role-play, students develop a role model and present the model in class, hence it is learner-centred approach. On the strength that it enhances pedagogical content knowledge for both the educator and learners, Akdeniz (2016) highlights that the strategy allows students to practice newly developed skills and stimulates PCK. Regarding the response that it can generate learner understanding of actual scenarios/ events and instantaneous feedback, there is support from literature. For example, Hidayati et al. (2018) observe that when role playing feedback is seen immediately and the educator can respond immediately to do corrections if there are mistakes done especially when dealing with experiments.

- **Weaknesses**

The strategy can be comfortable and/or embarrassing for some learners who are introverts, but educators may mix learners to cater for all of types. On being heavily reliant on learners' ability to actively participate, Hidayati et al. (2018) observes that it hinges on real life experiences. Other weaknesses pointed out are: It can degenerate into chaos if it is not monitored; everyone will be interested in roleplaying and ends up messing the learning material to be used; and it is applicable to a limited number/type of subjects.

Table 4-15: Quantitative results on strengths and weaknesses of question and answer

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Question and answer	Can be easily integrated with other teaching strategies	9	20	Requires particular skills from the teacher to be effectively used	5	25
	Useful in ascertaining learner understanding	12	26	It is particularly unsuitable for non-responsive learners	8	40
	Relatively simple to implement	12	26	Can be time consuming as it requires learners to be afforded thinking time	7	35
	Response and feedback can be immediate	10	22			
	Can be used to raise learner confidence	3	7			

On the merits of the question and answer method, 46 responses were provided. The most common views provided by the educators were that the method was relatively simple to implement and useful in ascertaining learners' understanding (12; 26% each). The participants further acknowledged that the question and answer method fostered immediate responses from the learners and feedback from the teacher (10; 22%) and could be easily integrated with other teaching strategies (9; 20%). The least provided strength of the model was that it could be useful in raising learner confidence.

The number of responses on the disadvantages of the question and answer method was only 20. Of these, the most common was that the method could be particularly unsuitable for non-responsive learners (8; 40%). The others were: it could be time-consuming as it required learners to be afforded thinking time (7; 35%) and required particular skills from the teacher for effective use (5; 25%).

- **Discussion**
  - **Strengths**

Educators responded that question and answer strategy could be easily integrated with other teaching strategies. For instance, students are able to interrogate the educator when not satisfied with the feedback. Discussion, presentation and brainstornming are strategies that can be intergrated with question and answer. Educators mentioned that the strategy was relatively simple to implement, promoted learners understanding immediately, response and feedback could be immediate and learner confidence could be boosted. Marzano (2003) states that the strategy improves students' ability to recover, use and organize what they already know about a topic. Akdeniz (2016) observes that question and answer encourages students to direct suitable questions to each other.

- **Weaknesses**

Educators pointed out that it required particular skills from the educator for effective use and that it was particularly unsuitable for non-responsive learners. It was also time consuming since learners needed to be given thinking time.

Table 4-16: Quantitative results on strengths and weaknesses of presentation

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Presentation	Speaking skills are promoted/ Learns to speak better/sharpens speaking skills	15	34	Memorization can be promoted	9	29
	Public speaking confidence is developed	10	23	Stage fright diminishes the quality of work by the learner	12	39
	Prepares learners to express themselves infront of the class	12	27	Time consuming during preparation	5	16
	Develops higher order thinking	2	5	Teaching process may be delayed	2	6
	Team work in preparing presentation/collaborate	4	9	In large classes fast learners are the speakers of the group	3	10
	independent thinking/logical thinking promoted	1	2			

For presentation strategy, educators identified 44 strengths. These in the descending order of number of responses were: promote speaking skills (15; 34%); prepare learners to be able to express themselves (12; 27%); public speaking confidence is developed (10; 23%); collaborative learning during preparation is enhanced (4, 9%); develops higher order thinking (2; 5%); and, independent and logical thinking is promoted (1; 2%).

The educators provided 31 responses on the weaknesses of the presentation strategy. The most commonly identified weakness was on stage fright during presentation that may diminish the quality of work (12; 39%). Other weaknesses in descending order of frequency were: promotes memorisation (9; 29%); time-consuming during preparation (5; 16%); fast learners are the speakers of the group in large classes (3; 10%) and teaching process may be delayed (2; 6%).

- **Discussion**
  - **Strengths**

An advantage which educators identified was that speaking skills were promoted/ students learned to speak better. Literature too acknowledges that the strategy stimulates good communication and presentation skills (Girard & Trapp, 2011). It develops public speaking confidence and equips students with communication skills (Zivkovic, 2014). Girard and Trapp (2011) emphasize that in oral presentation, students gain knowledge not only from research but also from other presenters while presenting. Team work, independent and logical thinking are promoted through the use of the stratregy. Girard & Trapp (2011) too obseve that the strategy encourages class interaction and contributions and develops presentation skills.

  - **Weaknesses**

As identified by educators, the strategy is not easy for some learners. Weaknesses develop due to the stage fright and also time constraints. However, Girard and Trapp (2011) explain that students gain experience not only from research but also from other presenters during the process of presentations. Weaknesses such as promotion of memorization, development of anxiety and dependence on fast learners who are very confident were also mentioned. Furthermore, the strategy may delay teaching process since there is a lot that needs to be done as sometimes students use technology resources and charts. It is also time-consuming according to educators. Considering the observation by Girard and Trapp (2011) that this strategy boosts class interaction and contributions, educators ought to find ways to minimise the weaknesses. For instance, when learners present, the educator can assist by correcting the mistakes so that both teaching and learning occur.

Table 4-17: Quantitative results on strengths and weaknesses of project work

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Project work	Encourages long term research work and skills in learners	9	21	Can be strenuous for both the learner and assessor	17	50
	Encourages planning and critical thinking skills	7	16	May require resources which are unavailable	13	38
	Can provide practical activities and assessments	13	30	May be irrelevant for learners subjected to standardised tests and examinations	4	12
	Fosters improved interpersonal communication skills	5	11			
	Fosters evidence-based learning and assessment	9	21			

The responses provided on the strengths of project work as a teaching and learning method were 43. These in descending order were: the method could provide practical activities and assessment (13; 30%); encouraged long term research work and skills in learners, fostered evidence-based learning and assessments and encouraged planning and critical thinking (9; 21% each). The lowest identified strength was that it fostered/improved interpersonal communication skills.

Only 34 responses were for disadvantages. They were: the method was particularly strenuous on both the learner and assessor (17; 50%); resources needed for some projects might be unavailable (13; 38%), and, projects might not be useful if learners were subjected to standardised tests and examinations (4; 12%).

- **Discussion**
  - **Strengths**

Concerning project work educators mentioned the strengths of the strategy as encouraging long term research work and skills in learners and stimulating critical thinking. Zajkov and Mitrevski (2012) observe that students are required to be more logical and think critically by analysing collected information to solve problems through project. On providing practical activities and assessments and on fostering evidence-based learning and assessment, Thomas (2000) observes that learning that involves students in investigations and problem solving gives students a chance to work autonomously in building their own knowledge. The strategy also stimulates interpersonal communication skills. Literature indicates that projects involve PBL and increase students' academic achievement, cooperation/collaboration, creativity, problem-solving ability and students' attitude towards learning (Sumarni, 2013).

- **Weaknesses**

Through experience, educators identified weaknesses such as it could be strenuous for both the learner and assessor; might require resources which were unavailable and might encounter difficulties in implementing. Blumenfeld et al. (1991) too noted that there were difficulties in implementing the strategy.

Table 4-18: Quantitative results on strengths and weaknesses of investigation

Strategy	**Strengths**	**Nº**	**%**	**Weaknesses**	**Nº**	**%**
Investigations	Encourages research and analysis skills in learners	10	18	Lack of apparatus and equipment can hinder the learning process	16	29
	Promotes cognitive and practical skills	12	21	Can be complex and difficult to manage	8	15
	Experiments can foster deeper understanding of concepts	17	30	Can be costly and impractical especially for rural schools	11	20
	Encourages hypothesizing and predictions which foster higher order thinking	8	14	Time consuming	13	24
	Raises questions and encourages practical solutions to realistic phenomena	9	16	Requires specialised skills from the teacher	7	13

On the investigation method, 56 responses were provided on the strengths. In descending order of frequency, the educators identified that experiments served as an investigative method which fostered deeper understanding of science concepts (17; 30%); promoted cognitive and practical skills (12; 21%); encouraged research and analysis skills in learners (10; 18%); raised questions and encouraged practical solutions to realistic phenomena (9; 16%) and encouraged hypothesizing and predictions which fostered higher level thinking (8; 14%).

The educators also identified and provided 55 responses pertaining to the weaknesses. The most common one referred to the unavailability of the needed apparatus and equipment in science education (16; 29%). Investigations were also identified as time consuming exercises (13; 24%); could be costly and impractical particularly in the rural schools (11; 20%) or might be complex and difficult to manage (8; 15%). The least provided response was that investigations required special skills on the part of the educators (7; 13%).

- **Discussion**
  - **Strengths**

Educators mentioned advantages of investigations as encouraging research and analysis skills in learners, promoting cognitive and practical skills, fostering deeper understanding of concepts and encouraging hypothesizing and predictions which fostered higher order thinking to bring about practical solutions. Woolnough, 1991) states that a scientific investigation is an all-inclusive approach to learning science through practical work. The objective of science investigation is to offer students opportunities to use concepts and cognitive processes and skills to solve problems (Got & Duggan, 1996). Furthermore, CAPS (DBE, 2011) mentions the cognitive and practical process skills in natural sciences which are: accessing and recalling information, observing, comparing and measuring.

  - **Weaknesses**

Educators mentioned weaknesses as lack of apparatus and equipment that hinder the learning process. The strategy can be costly and impractical especially for rural schools, time consuming and can be complex and difficult to manage. Mtsi, Maphosa and Moyo (2016) confirm that educators in South Africa encounter challenges in terms of science resources which inhibit science teaching. Furthermore, Mtsi and Maphosa (2016) mention that resources need to be available to enable proper teaching of science. Therefore, educators need support from the schools and other stakeholders to promote the use of practical work which needs relevant science material, especially in rural schools. Concerning the time factor, educators need to create time to allow learners to participate actively, as suggested by Bruner’s theory. It encourages active engagement, promotes motivation and autonomy, responsibility, independence as well as creativity and problem solving skills (Bruner, 1915).

4.5 Qualitative results on strengths and weaknesses of these strategies in promoting science learning and SL

The responses concerning strengths and weaknesses are found in the following sub themes: Strategies allowing active engagement, higher order thinking, educator-centred, advantages and disadvantages.

Table 4-19: Strengths and weaknesses of the identified strategies in promoting

Themes	Sub-themes	Related issues
Strenghts and weaknesses	Strategies allowing: Active engagement	• Demonstrations • Investigations • Question and answer • Research • Role-play
	Higher order thinking	• Investigations • Case study • Discussions • Problem solving
	Educator-centred	• Lecture method • Text book method
	Advantages: Active engagement	• Motivate learners. • Boost learners confidence. • Promote interaction. • Enhance critical thinking. • Sharing of ideas. • Able to think beyond.
	Advantages: Higher order thinking	• Co-operation • Allow interaction • Encourage learner participation. • Learners access information. • Ability to apply thinking and relate information. • Easy to link information with home environment.
	Challenges:Active engagement	• Time consuming. • Other learners tend to rely on others. • Learners become passive at times. • Copying from others.
	Challenges: Higher order thinking.	• Rely on others. • Plagiarism • Lack of resources hinder learning progress. • Memorization is promoted

	Advantages: Educator-centred	• Easy to communicate information • Learners receive information without applying research skill.
	Challenges: Teacher centred	• Memorization is promoted • Develop laziness and Inhibit research skills • Learners copy from others

4.5.1 Active engagement

Eristi and Akdeniz (2012) highlight two types of strategies i.e macro- and micro-strategies. Macro-strategies allow active engagement and micro-strategies enhance higher order thinking. Therefore, participants responded differently on strategies that allow interactiveness and deep thinking skills. Most educators responded:

> *Demonstration allows active engagement because everyone is assigned to do something (T1). Demonstration is working for me, most of the time I bring pictures in class. It gives learners to have a clear view of the topic. An example is whenever Hiv virus enters the body systems this is what it does, I also play a video to show them what is happening (T5). In addition, we are given a task to bring carrots, rice and potatoes. We are going to check the presence of starch using iodine solution (FG5).*

> *Question and answer method and experiment method allows interactiveness, I don't use it on its own I intergrate with other strategies. For instance answers I do not write them on the board immediately while participating I push them, drive them to arrive in the correct answer (T4).* Leaners response: *All of us participate in the lesson by answering questions, we chose wich group you want to join , we also ask questions from our teacher if we are not clear about the topic (FG4).*

Another educator mentioned that :

> *Role-play promotes active engagement, learners work on their own there is a lot of noise. The class becomes loud and noisy and monitoring is needed (T8).*

> *Tell me I forget and show me I will remember, demonstration, experiments and role-play they allow active engagement in class (T10).*

The shared views showed that active engagement is applied by both learners and educators. They promote interactiveness and develop critical thinking. The key practices are: demonstration, group work, experiments, question and answer and role-play.

4.5.2 Higher order thinking

Educators agreed that there are strategies that promote higher order thinking, usually they call it critical thinking. They revealed that:

> *Investigations promote higher order thinking. An example when giving learners a question it needs a conclusion at the end. So the learner will critically think what happened up to the last stage (T2).*
>
> *Case study promotes higher thinking e.g. When I give them questions like : What are stem cells? How do you get them? How are they harvested? Then learners will do a lot of thinking (T3). Problem solving, investigation and case study encourage higher order thinking and learners are able to voice out whatever they know and also ask questions (T9).*
>
> Another educator commented: *Discussions is promoting higher order thinking especially the small groups. Tasks must be structured in a way that learners can think beyond limit, going above grade 9 level (T4)*. Another response: *The following strategies promote higher order thinking: Discussions, Investigations, problem solving* (T7).

Most educators agree that investigations, case study, discussions and problem solving are working for them to promote higher order thinking and for learning science and promoting SL.

4.5.3 Educator-centred approaches

Most educators expressed the same views about some of the strategies that promoted educator-centred approach, leading to memorization. They stressed individual practice, lecture method and text book method. Educators pointed out that:

Question and answer is not good at times, learners tend to rely from other learners and copy (T4). You will find out some learners didn't understand anything, didn't follow the task given as individual when using lecture (T5). Lecture method I used it but it promotes laziness from learners they just receive information instead of looking for information. It is not even encouraged (T8). I use textbook and chalkboard when I teach because I don't have technology tools (T5).

4.5.4 Benefits of active engagement

Most educators indicated that active engagement enhanced science teaching. They mentioned the benefits as, motivating learners, boosting learners' confidence, promoting interaction, enhancing critical thinking, sharing ideas and ability to think out of the box. One educator's comment was:

Learners understand better when involved. They gain from others (T4)

Some educators expressed a positive attitude towards the use of active engagement in the teaching and learning of N.S highlighting that:

I believe active engagement promote science learning and SL, whenever we talk or demonstrate in class learners have knowledge to see neutral, positive earth wire. So they they are able to assist their parents even at home. That means the benefits goes beyond school to home (T6). Confidence is developed when learners are engaged and critical thinking is enhanced (T5). When I give my learners presentation task they have an opportunity to exchange ideas , therefore interaction is promoted (T6).

Learners articulated that:

At home my mother get confused why the electric kettle is not working, then I show her how to fix it using information from my N.S educator (FG5). At home if there is someone ill with constipation, we use the information we learn at school e.g., advice about good nutrition, eating a balanced diet and eating foods with lots of fibre. It is important to tell our parents that if a person lack high fibre the will become sick (FG4).

It is clear that there are benefits when learners participate actively, and according to participants, promotion of science learning and SL is enhanced, confidence is developed, critical thinking is enriched and ideas are shared.

4.5.5 Benefits of higher order thinking

Many educators agreed that higher order thinking allowed learners to think deeply and apply it. They mentioned the benefits of higher order thinking as: encouraging learner participation, promoting co-operation, ability to apply thinking and relate information, ability to access information from different sources and convenience to link information with home environment. Educators expressed that:

> *Learners are able to voice out what they know and also asks questions (T9). When we do research we divide work amongst us, we look for information and we discuss it (FG8).*

> *I give my learners Investigation to promote higher order thinking they look for information, at the end there is a questionaire that needs conclusion, therefore the learner will critically think what happened up to the last stage (T2). Investigation and problem solving allow learners to apply their thinking skills, dig deeper and at the end they are able to have more knowledge and more thinking (T5).*

The study found out that when learners were given tasks that promoted higher order thinking there were advantages such as promotion of thinking skills, increased learner participation exposing them to look for information from different sources as well as ability to use the learned information and relate it to their environment.

4.5.6 Challenges of both Active engagement and higher order thinking

Educators expressed their views concerning the macro and micro strategies. They indicated that the challenges of active engagement were: lengthy time , learners' tendency to rely on others and becoming passive at times. Challenges of higher order thinking were: lack of resources hindering learning, promotion of memorization and plagiarism. Some of the verbatim quotations are:

Learners who do not want to use their critical thinking will not try to attempt the question, and other learners do not participate because of large numbers in the classrooms. (T2). In active engagement strategies the weakneeses are: Lack of apparatus inhibits the N.S experiment process, at times to a large group constraint-is time factor. It is not effective to a large group it wont produce expectations (T10).

Sometimes memorization is promoted especially in large groups, and at times large groups are time consuming they affect the teaching and learning process(T10). Fast learners tend to dominate slow learners and progress of learning is affected (T9). Lack of participation due to lack of finances for instance if I ask my learners to do reseach they complain that they do not have data bundles to goegle the information from internet. As an educator it demotivates me too, if wifi was available none of the challenges will hinder the teaching and learning of NS (T8).

4.5.7 Main findings on the strengths and weaknesses of these strategies that promote science learning and SL

Results showed that there were benefits in these strategies and also challenges. They are furnished below in Table 4.20.

Table 4-20: Summary of the findings

Findings (Quantitative data)	**Findings (Qualitative data)**
Various strengths were provided by the educators on the strategies which promote active engagement in learners. The demonstration, discussions, project work and role-play strategies provided the commonly selected strengths of encouraging learner participation; promoting constructivism; providing practical work and understanding actual events.	Key practices in active engagement are: Demonstration, Investigation, , projects, question and answer and role-play.
	Agreed on benefits of active learning as: Promotion for science learning and SL, confidence is developed, critical thinking is enhanced and ideas are shared.
The strategies which promote higher order thinking had the main advantages of promoting learner collaborative approaches and fostering deep thinking and; skills are transferrable to real world events.	Higher order thinking is promoted through the use of investigations, case study, discussions and problem solving
	Confirmed the benefits of higher order thinking as :thinking skills are promoted, encourage learner participation, expose them to look for information from different sources and ability to use the learned information and relate it to their environment .
Several weaknesses were recorded as the most common; time consumption; lack of participation by timid students who may be dominated by more active and engaged learners; the methods could be costly in some instances.	Admitted that there were challenges in active engagement: time consuming, learners tened to rely on others and learners became passive at times. Challenges faced in higher order thinking: Lack of resources hinder learning, Memorization and plagiarism are promoted. Lack of participation due to lack of finances.
	Confirmed that teacher centred method was promoted through the use of lecture method and text book method.
	Challenges regarding teacher centred method are : Learners copy from others, become lazy, promotes memorization

4.5.8 Interpreting the triangulation table

The summary of findings in Table 4.20 above shows that there is consistency in the responses from the educators. The methods which they viewed as learner-centred and promoting high order thinking were identified as those which they would use to promote learners to be active, to participate and to think critically. The educator-oriented method was identified in both the quantitative and qualitative part of the study as the lecture method. In qualitative results higher order thinking was confirmed. The researcher assumes that it is because learners learn research skills which assist them when doing tasks that need critical thinking. Although these strategies have benefits that enhance science learning there are also challenges experienced by educators. Key findings showed that demonstration,investigation, projects, question and answer and role-play are strategies that allowed for active engagement. Benefits of applying active engagement strategies were: promotion for science learning and SL, confidence development, enhanced critical thinking and sharing of ideas.

The strategies that promoted higher order thinking were as follows: investigations, case study, discussions and problem solving. The study confirmed the benefits of higher order thinking as: promotion of thinking skills, encouraging learner participation,enhancing research skills and fostering deep thinking. Skills are transferrable to real world events thus helping learners to link the new information to their environment. Lecture method was identified as the educator-centred method, which promoted chalk and talk with no interactive learning. The study further revealed that there were challenges in active engagement such as: lengthy time, learners' tendency to rely on other learners and becoming passive at times. Challenges in higher order thinking were as follows: lack of resources hindering learning, promoting memorization and plagiarism as well as lack of participation due to financial constraints. Challenges regarding educator-centred method were: Learners copying from others, becoming lazy and promoting memorization.

4.6 Results on educator support for science learning and promoting SL

The research question above sought to examine the support given to educators for science learning and promoting SL. The present research was focusing more on what support structures the administration has put in place for science educators to ensure effective teaching of science. Educators responded differently. Learners were also asked this question in their FGs. Furthermore, the researcher was more interested to know if learners got support from their parents, educators and their peers and they too responded differently.

4.6.1 Quantitative results on educator support for science learning and promoting SL

Research guiding question: Which of the following strategies are used to support educators for science learning and promoting SL in schools? Respond to each row.

Table 4-21: Strengths and weaknesses of cluster support

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Cluster support	Sharing of science kits.	12	23	Time may not always be available	16	62
	Assists in collaborative content development.	10	19	Requires resource input on the part of teacher	10	38
	Assists each other in the common practical tasks	14	26			
	Cooperative development of examinations, memos, lesson plans, study guides	17	32			

Under cluster support strategy, 53 responses on the strengths were provided. The majority of the respondents stated that the main advantage of being involved in cluster support was that it fostered cooperative development of examinations, memos, lesson plans and study guides (17; 32%). The next lower strengths identified were: they assisted one another in performing common practical tasks (14; 26%); shared science kits which were used in the practical lessons (12; 23%) and were assisted by cluster support in collaborative content development (10; 23%).

The educators provided 26 responses on the weaknesses associated with cluster support. Out of the two weaknesses provided, (16; 62%) the responses identified the unavailability of time as the main one. The second weaknesse identified (10; 38%) was that the process required educators to sacrifice resources to access cluster support.

- **Discussion**

Concerning cluster workshop, educators mentioned the following strengths: sharing of science kits, assisting in collaborative content development, assisting each other in the common practical tasks and cooperative development of examinations, memos, lesson plans, and study guides. Regarding the strengths mentioned above, literature shows that clusters enhance educator's content knowledge and pedagogical content knowledge. Furthermore, there are benefits when working as a cluster such as educators assisting each other in classroom practices, doing common planning like setting common assessment tasks and doing team teaching in different schools using relevant resources (Jita & Mokhele, 2014). Cluster workshop team also prepares common pace setters to make sure that they all teach the same content that is displayed by the policy document (Jita & Mokhele, 2014). Therefore, cluster workshops serve as a source of support to science educators and enhance the quality of science teaching. Nkambule and Amsterdam (2018) confirm that educator support is good for mentoring, coaching and professional development.

- **Weaknesses**

Educators mentioned the following challenges regarding cluster workshops: time may not always be available and it requires resource input on the part of educator. CAPS (DBE, 2011) specifies the instructional time for NS senior phase as three hours a week and hence educators highlighted the time factor as a weakness due to the workload that demands both theory and practical. Bantwini and Diko (2011) highlight that most schools cannot afford to purchase science equipment to support effective teaching and learning in schools and therefore science teaching may be negatively affected. Resources are very important as science is a practical subject. CAPS (DBE, 2011) emphasizes the use of resources when teaching science. In addition, Mtsi and Maphosa (2016) note the challenge of lack of resources when basic requirements are not available and effective teaching of science cannot be promoted.

Table 4-22: Strengths and weaknesses of workshops offered by district offices

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Workshops offered by District Office	They visit schools for intervention support.	15	27	May be intimidating for some educators	16	
	Offer training and staff development workshops.	14	25	Often disrupt normal learning and teaching	10	

	Offer assistance in content gap.	17	31	Often require feedback on progress which educators may not be ready to provide	5	
	Motivate participation in science competitions and interactive teaching.	9	16			

The workshops offered by the district office of the DBE generated the largest number of responses particularly on the advantages which they offered to teaching and learning. Concerning workshops offered by the district office of the DBE, 55 responses were recorded. The most common advantage associated with the participation of the district office in supporting educators was that they offered assistance in covering content gaps (17; 31%). Secondly, the DBE district office was stated as offering intervention support in schools (15; 27%). The next advantage in popularity was that the district office offered training and staff development programs (14; 25%). The least recorded advantage was that district visits motivated participation in science competitions and interactive teaching (9; 16%).

Several disadvantages of district officials' workshops were presented. 31 responses were recorded. The most identified demerit was that such programs often intimidated educators (16; 51%). The remaining disadvantages as perceived by the educators were that the visits were often disruptive of teaching and learning activities (10; 32%) and that during post-workshops, the DBE officials often required feedback from the educators (5; 16%).

- **Discussion**

Advantages pointed out by educators on workshops offered by the district were as follows: they visit schools for intervention support; offer training and staff development workshops; offer assistance in content gap; motivate participation in science competitions; and promote interactive teaching. Literature highlights that educator support is a vital ingredient in the work of education systems across the world and educators require support as they try to find their feet in the profession (Nkambule & Amsterdam, 2018). Moreover, National Education Evaluation & Development Unit, (2013:15) mention the tasks needed to be done by the Education districts and circuit offices as to ''conduct school visits, classroom observation, consultation and cluster meetings." Department of Education (DoE, 2008:22) stresses that "education district officials are obliged to visit all schools within the district at least once per term". The present researcher is of the opinion that the frequent visits in schools by DoE officials will assist educators in the implementation of science curriculum, solve challenges experienced by educators and also boost their confidence in teaching the subject.

- **Weaknesses**

The disadvantages mentioned were: it might be intimidating for some educators, often disrupted normal learning and teaching and required feedback on progress which educators might not be ready to provide. As mentioned by National Education Evaluation & Development Unit, (2013:15) education district officials are obliged to visit all schools to give support.

Table 4-23: Strengths and weakness of workshops offered by NGOs

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Workshops offered by NGOs	Assist with science kit.	15	34	They do not offer assistance in all schools.	18	69
	Visit schools for assistance in science content	16	36	Struggle with resources	8	31
	Offer development training	13	30			

Non-governmental organisations collaborate both directly and indirectly with government departments to improve science learning and SL. The educators provided 44 responses on the advantages brought about by NGOs in the promotion of SL. The most commonly selected advantage was that NGOs visit schools and collaborate with schools to offer and improve science content (16; 36%). Close in popularity was that they assisted through providing science kits for schools and learners (15; 34%). The least cited was that NGOs offered development training (13; 30%).

Two drawbacks associated with participation of NGOs in supporting SL were recorded with 26 responses. The more common of the two was that NGOs did not offer support to all the schools (18; 69%) and the less common was that NGOs generally struggled to generate sufficient resources for the level of support required (8; 31%).

- **Discussion**

Strengths of the workshops offered by NGOs: assist with science kit, visit schools for assistance in science content and offer development training. A programme called Technology Research Activity Centre (TRAC SA) is playing a role in supporting educators in science, mathematics, and technology education in schools (Gosa, 2018). The programme is in partnership with Eastern Cape Department of Education. They assist government by providing support in improving quality education through the use of trainings, giving science toolkits and encouraging the use of different exciting methods to teach science. National Education Collaboration Trust (NECT) is another programme that supports science educators. The programme provides practice-based support for educators to improve the quality of teaching (Curriculum Instruction G03/2017).

- **Weaknesses**

Weaknesses mentioned by educators are: NGOs do not offer assistance in all schools and struggle for resources. TRAC was implemented only in 30 selected schools and in five districts in the Eastern Cape Province (Go & Express, 2018). Not all schools received the support from other NGOs. NECT programme is also implemented only in a few schools.

Table 4-24: Strengths and weaknesses of workshops offered by Provincial (DBE)

Strategy	**Strengths**	**Nº**	**%**	**Weaknesses**	**Nº**	**%**
Support by Province (DBE)	Visit schools for support.	23	44	Often do not visit at all	5	16
	Motivate through provincial teaching awards.	11	21	No material support offered	26	84
	Offers staff development exercises	18	35			

Discussions on support offered by the provincial office of the DBE generated 52 responses for advantages. The most common advantage identified was that they often conducted school visits (23; 44%). Secondly, the DBE provincial office was stated as offering support in schools (18; 35%) through staff development exercises. The least recorded advantage was that provincial officials motivated educators through provincial teaching awards (11; 21%).

Only two disadvantages regarding the provincial office were presented among the 31 responses recorded. The most identified disadvantage was that the provincial office often did not offer any material support for educators (26; 84%). The remaining disadvantage as perceived by the educators was that the provincial officials did not visit often (5; 16%).

- **Discussion**
    - **Strengths**

Responses from educators concerning the support from the Province (DBE) were: visits schools for support, motivates through provincial teaching awards and offers staff development exercises. Literature demonstrated that DBE gives "support for the professional development of managers, educators and administrative staff members and holds education institutions in a district area to account for their performance" (National Education Evaluation & Development Unit, 2013:15). Supporting educators is also done in other countries. For example, data from Australian Institute for Teaching & School Leadership (2012), Abbott, Middlewood & Robinson (2014), Li & Zhang (2015) and Moore (2016) show high performing countries such as Finland, Australia, Japan and United States making significant investments in educator training, educator induction, educator development and professional development with considerable emphasis on collaboration.

- **Weaknesses**

Concerning the Provincial support, some educators mentioned that they did not visit at all and no material support was offered. This can impede science curriculum implementation and both educators and learners may be negatively affected. Literature shows that duties of curriculum advisors are not well-coordinated between district office and circuits and also at the provincial level. Bantwini (2009) and Brynard & Netshikhophani (2011) note that absence of support from the district personnel has been exacerbated by the lack of school subject area committees to guarantee that educators assist each other in challenges they encounter.

Table 4-25: Effects of the awards given to the science educators

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Awards given to educators for their hard work (DBE)	Create confidence when teaching the subject.	12	29	Little participation by educators	8	26
	Stimulate team work	5	12	May demotivate non-winners	23	74
	Encourage additional effort	24	59			

The respondents listed three advantages of awards given to educators in recognition of commitment and hard work. There were 41 responses provided. Out of these, the most common was that awards encouraged additional effort (24; 59%). This was followed by: awards fostered confidence in educators during their work (12; 29%) and awards could stimulate team work (5; 12%).

Two disadvantages were provided by the respondents in 36 responses. The majority of the responses (23; 76%) indicated that awards might demotivate non-winning educators. Other responses indicated that awards were not particularly useful since most educators did not participate in the processes (8; 26%).

- **Discussion**
    - **Strengths**

Educators mentioned that awards created confidence when teaching the subject, stimulated team work and encouraged additional effort. DBE National Teaching Awards (2018) clarified the purpose of the awards as to motivate and support educators. Definitely, when educators receive awards they become motivated and more confident. DBE NTA (2018) states in the objectives that the focus is to identify and promote excellence in teaching performance. ECDoE 2015-2019 strategic plan (2015) stressed that Department of Education was aiming at recognizing inclusive life-long learning and knowledge societies. With regard to the above, when DoE is promoting life-long learning, educators will walk the extra mile with these awards and become more inspired to implement the curriculum effectively.

- **Weaknesses**

Educators mentioned little participation by educators and demotivation for non-winners. In competitions an individual may lose or win, but it does not mean a person must give up. Instead, a dedicated educator, an expert in the subject may continue modifying his/her skills to win the competition. However, educators may lose interest because they are demotivated for different reasons, among them negative attitudes and lack of pedagogical content knowledge. Shulman (1986) states that an expert educator is able to teach effectively if he/she has knowledge and understanding. Literature indicates that pedagogical content knowledge is educators' understanding of how to help learners understand a specific subject (Magnusson, Borko & Krajcik , 1999). Therefore, when educators lack content knowledge they may develop demotivation and little participation may occur for the awards.

Table 4-26: SAASTA's strengths and weaknesses

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
SAASTA - science resources	Resources assist in conducting practical tasks.	30	67	Considers few schools (we never get assistance from SAASTA).	17	55
	Allows learners to participate	15	33	Resources not available to all.	14	45

With reference to SAASTA support with science resources 45 responses were recorded on the advantages side. The most commonly listed advantage was that

SAASTA resources were very useful when conducting practical tasks (30; 67%). The other listed advantage was that the said resources allowed learners to participate in practical learning (15; 33%). Responses on the disadvantages consisted of 37 responses. The most selected disadvantage was that SAASTA considered few schools and others did not receive support (17; 55%). The other disadvantage was that resources were not available to everyone.

- **Discussion**
  - **Strengths**

Educators mentioned advantages concerning SAASTA science resources as: resources assisted in conducting practical tasks and allowed learners to participate. There is a mobile laboratory jointly funded by DST, SAASTA and Sasol Inzalo Foundation (SAASTA (2016). The mobile is meant to assist educators in conducting practical tasks. The programme Globe under the Department of Science and Technology's 'youth into science' strategy plays a role in promoting science learning and SL among the youth through science engineering and technology related careers (SAASTA, 2016). CAPS (DBE, 2011) specific aim 1 stresses that learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions. Therefore, practical tasks are emphasized by the policy, and SAASTA is elaborating more about the resources which play a big role in conducting practical tasks effectively. CAPS also emphasizes the use of resources when doing practical tasks in each topic in order to assist educators with planning and preparation CAPS DBE (2011).

  - **Weaknesses**

These are: resources are only for a few schools, never get assistance from SAASTA and resources are not available to all. Literature demonstrates that lack of resources and support is a challenge facing rural schools (Phasha et al. 2016). Therefore, if some schools are not getting assistance in terms of resources, they get demotivated and learners will not be able to get quality education. Diko (2011) emphasizes that most schools cannot afford to purchase science equipment to support effective teaching and learning at schools. In order to get support from SAASTA programmes, educators need to join and work as teams with schools already participating. SAASTA will not know and look for schools because South Africa is a large country and servicing many schools in each Province can be a challenge. Therefore DoE should try to assist schools or educate schools to make use of SAASTA programme.

Table 4-27:SAASTA content knowledge support

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
SAASTA - content knowledge	Benefit a lot in content clarification.	17	42	Not all benefit from the programme.	18	55
	Extra resources availed	23	58	Few schools benefit.	15	45

The SAASTA content support responses were limited. Only two advantages and disadvantages each were provided. 40 responses were listed on the strengths. The most common of the responses was that SAASTA content assistance was useful as it provided extra resources (23; 58%). The other advantage was regarding the assistance on clarification of syllabi (17; 42%). The weaknesses associated with SAASTA content knowledge support were directly related to SAASTA resources. The more common of the two was that not all benefited from the assistance (18; 55%). The other weakness was that few schools benefited from the programs (15; 45%).

- **Discussion**
  - **Strengths**

The participants mentioned the following strengths: Benefiting a lot in content clarification and availability of extra resources. SAASTA (2016) states that it supports the educators to teach science effectively and gives away science material as resources, e.g., mobile laboratory. Nkambule and Amsterdam (2018) emphasize that educator support is a vital ingredient in the work of education systems across the world and that educators require support as they try to find their feet in the profession, make sense of reform initiatives and implement policy.

  - **Weaknesses**

Educators highlighted some of the weaknesses: not all of them benefit from the programme-only few schools benefit. The main purpose of this project is to improve learners' performance in science and mathematics and to also empower educators (SAASTA 2016). If educators lack content knowledge and experience challenges that inhibit the teaching of science, they will not participate. SAASTA also provides laboratories to schools. Both quantitative and qualitative data show that not all schools perform practical work due to lack of material relevant for the purpose. Other educators also lack knowledge. Literature reveals that educators need professional development on content knowledge (Kriek & Grayson, 2009). In addition, Mestry, Hendricks and Bisschoff (2009) emphasize that the quality of educators has a positive influence on the quality of learners' achievement, and the overall performance in the education system. Moreover, Phasha et al. (2016) mention that quality education can be enriched only if educators' challenges such as lack of resources, support and feedback from the authorities are considered. These challenges are faced especially by rural schools.

Table 4-28: Strengths and weaknesses of group work support

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Group work	Educators work collaboratively to clarify the tasks.	23	43	Has never participated/lacks knowledge.	7	29
	Learners can get chances for interactive learning	9	21	Some educators have no interest in collaborative work	17	71
	Presents chances for conferencing with experienced educators	21	40			

The educators gave 53 responses on the strengths of group work. The most provided responses were that group work allowed educators to work collaboratively to clarify tasks (23; 43%) and that it presented chances for conferencing with experienced educators (21; 40%). The least provided response was that group work might even allow learners the chance to interact (9; 21%). On the weaknesses portion, 24 responses were provided.

- **Discussion**
    - **Strengths**

In group work, educators mentioned that the strategy was working for them and they were able to work collaboratively to clarify the tasks, learners would get chances for interactive learning and for conferencing with experienced educators. Adamson, Santau and Lee (2013) stress that through engaging educators to collaborate, learning process can make a difference and it can also be a part of ongoing professional development. Furthermore, Mbowane et al (2017) emphasize that when learners are actively involved in science, their skills are sharpened and educators have a significant role to play in science events. They should work together and do mentoring to enhance science learning. Therefore, the present researcher is of the view that when educators work together and organize science events it might be easy to assist those educators with content challenges and learners can develop more interest in the subject.

- **Weaknesses**

Some educators mentioned that they never participated in working as groups and so they lacked knowledge. Others state that they have no interest in collaborative work. Lack of involvement of subject area committees to work with the district officials can demotivate educators in working as groups (Bantwini 2009). Hence there should be good relations and interaction between subject advisor and subject committees, so that they can work together to improve the quality of the subject. Consequently, literature confirms that educators who teach a subject in a school must be supported by experienced educators, educational researchers, advisors and inspectors (Ellis, 2007). That means for educators to have interest to work together, all of the above mentioned stakeholders must play a role to motivate educators because when educators who teach science do not work co-operatively, leaners can be affected negatively.

Table 4-29: Strengths and weaknesses of science expos

Strategy	Strengths	Nº	%	Weaknesses	Nº	%
Science Expos	Competitions are accessible.	7	23	Never participated in any expos	4	33
	These competitions are motivational and educational	14	47	Learners may not be eager for extra load	8	67
	New practical skills are acquired	9	30			

Science expos as strategies used to support received 30 responses with three advantages. The most commonly selected strength was that the expos are not only educational but also motivate educators to perform better (14; 47%). The attainment of new practical skills was the second most commonly selected strength (9; 30%) followed by accessibility of competitions (7; 23%). Only two weaknesses were identified which were that some learners showed no eagerness to participate in events which increased their work load (8; 67%); and secondly that educators had never participated in any science expos (4; 33%).

- **Discussion**
  - **Strengths**

Concerning science expo, educators gave the following strengths: Competitions are accessible, these competitions are motivational and educational and new practical skills are acquired. Mbowane, Devilliers and Braun (2017) indicate that skills in mathematics and science learners are priorities and the government supports them through the Department of Basic Education (DBE) and the Department of Science and Technology (DST). In addition, literature shows that science fair events are projects that are educational and they contribute to pedagogical content knowledge (Mbowane et al. 2017). Furthermore, the programme Globe also nurtures young people’s talent for science engineering and technology related careers (SAASTA, 2016).

  - **Weaknesses**

The weaknesses mentioned by educators were that some of the educators never participated in any expos and learners might not be eager for extra load. The present researcher assumes that when educators develop negative attitudes in the subject and teach a subject that is not their specialisation or encounter other challenges, they may feel demotivated and not encourage their students to like the subject. Literature observes that in some instances educators are just given the policy documents to study and are expected to apply the information in the classroom, then educators become confused and implement the curriculum incorrectly (Bantwini, 2009). Therefore, educators might not participate because they feel stressed about the subject. Futhermore, literature explains that inadequate subject matter and support given to educators while teaching subjects in which they are not specialists can affect their curriculum implementation (Phasha et al., 2016) negatively.

4.6.2 Qualitative results on educator support for science learning and promoting SL

Educators were interviewed on how they obtained support for science learning and promoting SL. Educators' views fell into the following sub-themes: Availability of workshops, support structures like educators, Department of Education, Province, NGO's and emergency intervention.

Table 4-30: Theme and sub-themes on educator support for science learning and promoting SL

Themes	Sub-themes	Related issues
Educator support	Availability of workshops	Most educators confirmed that they attended workshops. Other educators do not attend. Some attend but claim they are not fruitful.
	Support structures: Educators	Hod's assist them. Educators in schools assist each other
	DOE	Most educators mentioned that they got support from the district' Some educators claim they do not get support.
	Province	Some educators get support from the Province Some do not get support at all Some highlighted that they got support but for other grades

	NGOs	TRAC SA (Eskom programme for science) is supporting and NECT
	Emergency intervention	Science kit to conduct experiments. Workshops to close the content gap. Assistance in conducting practical tasks in schools. Training e.g., get a diploma in N.S /Physical science.

4.6.2.1 Availability of workshops

CAPS policy document emphasizes that schools must make every effort to ensure that the essential equipment is provided. Tools, apparatus, materials and consumables must be acquired through a planned budgeting process. Secure storage for equipment must be provided by the school and adequate training and support including in-service empowerment workshops for educators are essential. Therefore, it is important that schools need support to link with what is emphasized by the policy. Both the educator and the learner need support to successfully promote the teaching and learning of science. Educators indicated the positive and negative experiences concerning availability of workshops. Some educators confirmed that they had obtained support while others did not get any support. Three educators mentioned that:

> *The last time I attended a workshop it was 2015, from 2016 up to date I never attended any workshop. I cannot remember things done in 2015 (T1). Another educator confirmed that she was never called to a workshop (T2). Never received any workshop, I don't even know when there is a workshop (T5). When I attend the workshop it is not working for me because they are too theoretical than practical, we need practical part of N.S (T8).*

Other educators responded :

> *I attended workshops even now there is a workshop that I will attend. It is a new programme called NECT (National Education Collaboration Trust), it is an organisation committed in strengthening partnerships within civil society and between civil society and government in order to achieve South Africa's national goals for basic education. It concentrates on content coverage to check if what*

you were supposed to do you covered it. Really I could say workshops improved my teaching (T3).

Some educators also confirmed that they had received support through workshop:

Workshops play a very good role, they target topics that are challenging and improve the way I teach (T4) and (T7).

It was clear that educators were not in agreement concerning educator support and availability of workshops. Some did not get them at all, while their colleagues did. Some are satisfied but others complain that some of the workshops are theoretical not practical.

4.6.2.2 Support structures: Educators

Educators explained their understanding of the concept support as LTSM which included books and resources in school. They also mentioned that they assisted each other in conducting the lesson, content coverage, challenges and working together.

Participants revealed that Heads of Departments (HoDs) and other educators assisted them too.

My HoD assist me in chapters that I have content gap and he is a science specialsit (T1). At my school they assist me when I need materials. We also have science days as (department of science) to showcase theory and practical (T7).

We as educators we assist each other when we encounter some challenges. (T9). Colleagues at work support each other (T5).

FG transcripts confirmed the above verbatims and they felt enthusiastic about the support they got from N.S educators:

Yes, we do get support form our teacher, she explains clearly, we do visit the teacher during break time when we need more clarity (FG2 and FG3). Our *teacher support us especially when we get lower marks she gives us another chance by asking us if we need another task, and she assist us a lot (FG5). Our teacher is an easy person to approach he can assist us even during his spare time (FG8).*

4.6.2.3 Department of Education

District officials in the Department of education are the ones who give support to the teachers e.g., inviting educators to workshops. They are playing a significant role according to various educators. They also go the extra mile by supplying science kits to N.S educators.

When the educators were probed on the support given by DOE they gave different responses:

> *I never received N.S workshop from the DOE science official the whole last year till now, I hear that there is science expo and I cannot attend due to lack of resources (T1).*

The statement is supported by another educator complaining about lack of support from the DOE:

> *I do not get the support from the district official, I just get support from physical science teacher in my school. The district just come to look for the tasks done by educators (T2). No support from the district like taking learners to go to N.S workshop to observe the practicals, just like in Technology we go with learners to do practical work. We do not even know when there is a workshop (T5).*

Other educators responded positively about DOE support voicing out that:

> *District of Education Officials came and assist me in my school, the science kit we have here come from the district office (T4). Last year I attended a cluster workshop organised by DOE, they knew that N.S learners form junior secondary move to senior secondary and we are not trained to teach grade 9, we are used in teaching grade 12. However, I still have a challenge in teaching grade 9 (changing of strategies to fit the lower grade) since Iam used in older*

learners (T4). Senior Education Specialist for N.S is responsible for workshops, supporting us with books to use, experiments and content coverage challenges (T6). I do get the support from DOE (T7) and (T8).

4.6.2.4 Province

Support from the Province is imperative to develop educator motivation in the teaching and learning process. Educators narrated different experiences pertaining to support in NS by the Province. Some were new and did not experience the visits yet.

I do not remember people from the Province (Education) come to my school for support in science (T1). We do not get the support from the Province (T8) (T2).

This year the Province came to my school three times specifically for grade 8 and 9 for natural science and technology (T4). Not yet experienced the support in science when they come they come to school general not to science educators specifically (T5). The Province do assist us to attend workshops not for grade 9 but for grade 10, 11 and 12 (T7) and (T9). The Province is really supporting us, we receive a lot of materials that we use when we go to learners (T10).

4.6.2.5 NGOs

Non-governmental organizations are organizations that contribute without expecting profit. Concerning the support, some educators confirmed that there was assistance from NGOs.

There is a programme that support us as in natural science, it is called TRAC SA. It is a science enhancement initiative support programme in the Eastern Cape. It is tracking if you are going at the right pace. If the CAPS document specifies the time to finish the content, then the teacher is accountable. If the educator didn't finish the work expected, you have to account. They also assist in content gap (T3). It is also confirmed by another N.S educator, highlighting that TRAC SA – by ESKOM is supporting educators (science).There is a tutor from Eskom who goes around the school to give support. He comes for grade 11 and 12, then I got the opportunity to ask for assistance in my grade 9 class.

The tutor assists me with apparatus, he said I can borrow them anytime I need them since Iam struggling with science kit (T10).

The response shows that NGOs are supporting science and some grade 9 educators are benefiting. Some educators are complaining that DoE rarely visits schools so they do not get support both from the district and the Province.

4.6.2.6 Emergency intervention

Most educators emphasized the need for urgent intervention concerning the N.S.

I am interested in something concerning natural science diploma,certificate or any knowledge in physical science. At the training college maths was going with physical education, therefore science is not my specialization (T2). I need urgently full material e.g laboratory to have everything for science. I do not have electric materials to do electric simple circuits, science is a practical subjects that needs more demonstration (T3) and (T9). I need resources , textbooks and science kit, the one that I have is not enough for my classes, since this year numbers are more so I need more. I have only one text book for grade 9 that came from junior secondary school, I am always fotocopying (T4).

I need assistance in practical tasks the how part, I ecounter challenges . If I can get a person to familiarize me, teaching us how to do these practicals. Each term experiments are suppose to be done, then we are required to do a practical task in each term, If I can be assisted to do more than one experiment not to rely only on one per term (T6).

If we can be assisted by Department of Education by organising more workshops, also to visit us in our schools to assist us in practical tasks so that as educators we observe and get confidence in conducting the experiments infront of the class (T5) and (T7).

Another educator was very stressed with the challenges in resources:

What I would want is material and apparatus to do the practicals. I wish I can have my own staff so that I can do practicals anytime when I want to, rather *than moving around borrowing from others. N.S is an abstract subject to learners it needs not to be taught theoretical. Natural science is a background to grade 12, background to tertiary institution that is why we have a lot of drop outs in the science field, we do not have background in practical, hands-on and science learning and promoting SL will not be promoted (T10).*

One educator emphasized that:

I do not not need any support because Iam not the specialist in the field. I need to be changed back to humanities. I need someone who can replace me, I do not qualify to teach N.S I get lost especially in chemistry. I always depend on my HOD for assistance (T1).

Other responses came from learners commenting that both their parents and educator gave support for science. Learning responses from educators showed that urgent intervention was needed because the process of teaching and learning would be negativey affected without support.

4.6.3 Summary of main findings on how are educators supported for science learning and promoting SL

Table 4-31: Summary of the findings

Findings (Quantitative data)	**Findings (Qualitative data)**
The quantitative findings show that workshops are a commonly used method of support for educators. The majority of the respondents attested to the advantages attained by attending workshops by both the province and district. These were largely tallying with those reported in qualitative collection.	Other educators confirmed that workshops were available and they were benefiting from them. Others claim that they have never attended a workshop and they are experiencing challenges. They claim that workshops are more theoretical than practical.
Inter and intra-schools support systems were proved to be a popular structures among the educators. Many of the respondents admitted to the advantages of mostly fostering cooperation and team work among educators.	Educators confirmed that they assisted each other and Heads of Department assisted too.
The respondents admitted that they had received support from the Department of Education provincial offices. The most commonly stated advantage was that the provincial officers visit schools for support and was listed 23 times.	It has been confirmed that DOE is supporting educators. There were also a few complaints that DOE was not visiting some schools to give support.

The most listed weakness was that no material support was offered most of times. This was stated 26 times.	Confirmed that the Province was giving support to educators,but some did not get the support at all. Others mentioned that they got support from the Province but for other grades e.g grade 12.
Support from NGOs was received through workshops which they organised. Acknowledged receiving support through this measure. NGOs stated that they provided science kits to schools 15 times and that they provided content support 16 times.	Non –Governmental bodies are playing a momentous role.
The quantitative responses reflect that educators most likely have serious resource and content constraints as they are not linked with centres which assist in the sciences area. The outcomes show that only a few were receiving resource support from SAASTA while only few acknowledged content support from the same organisation. This can be inferred from the large number of responses which indicated that SAASTA support covered few or selected schools in their area.	Emergency intervention :Resources for science are needed urgently. Content coverage through workshops. Assistance in conducting practical tasks. Training to get a Diploma or certificate in N.S or Physical science. One teacher emphasized that he was not interested in any support, just needed to be shifted back to humanities.

4.6.4 Interpreting the summary of findings

Table 4.31 above illustrates the consistency and alignment between the quantitative and qualitative responses. The qualitative section showed the general and non-numerical responses of the educators when expressing their stance in terms of forms of support which they had received in their work. The quantitative part showed numerically the level and measurements of support for the respondents. The evidence shows that the respondents were stable in their responses. Educators in qualitative responses complain about the lack of support and mention the necessity of an urgent intervention. Even in the quantitative part they need centres which will assist in science. Key findings were the confirmation from educators that workshops were available and they were benefiting from them.

Educators also confirmed that they assisted each other besides the assistance received from HoDs. Science educators confirmed that DoE offficials were giving tremendous support. It was revealed that the Province was giving support to educators but some did not get the support at all. It was confirmed that NGOs also supported the educators. Other support and motivation for educators were awards given to educators for their hard work, cluster support, SAASTA support and science expos.

Emergency intervention such as resources for science learning and SL is needed urgently to conduct practical tasks and content coverage through workshops.

4.7 Which strategies are relevant in enhancing science learning and SL?

Concerning the research question above, the focus was on the most relevant and least relevant strategies that are appropriate for improving science learning and promoting SL. One strategy is technology intergration, for instance, the use of ICT when teaching. In science inquiry which is another strategy, there are five methods that are under the strategy: simulations, experiment, demonstration, project work and fieldwork. The last strategy is predict-observe-explain strategy which deals mostly with the practical part of science and also predicts what will happen before they observe. The aim of the strategy is to emphasize the importance of predictions in science subjects. Learners must also be able to explain reasons behind their predictions

4.7.1 Quantitative results on the strategies that are relevant in enhancing science learning and promoting SL

Table 4-32: Strategies that are relevant in enhancing science learning and promoting SL.

Strategies	**Responses**	**Frequency**	**Percentage%**
Demonstrations	Most relevant	23	77
	Relevant	4	13
	Not relevant	3	10
	No response	0	0
	Total	**30**	**100**
Problem solving	Most relevant	26	86
	Relevant	3	10
	Not relevant	1	3
	No response	0	0
	Total	**30**	**100**

Simulation	Most relevant	4	13.3
	Relevant	15	50.0
	Not relevant	4	13.3
	No response	7	23.3
	Total	**30**	**100**
Inquiry	Most relevant	12	40.0
	Relevant	14	46.7
	Not relevant	3	10.0
	No response	1	3.3
	Total	**30**	**100**
Case study	Most relevant	**7**	**23**
	Relevant	**21**	**70**
	Not relevant	**2**	**7**
	No response	**0**	**0**
	Total	**30**	**100**
Lecture	Most relevant	2	7
	Relevant	7	23
	Not relevant	21	70
	No response	0	0
	Total	**30**	**100**
Discussion	Most relevant	**10**	**34**
	Relevant	**16**	**53**
	Not relevant	**4**	**13**
	No response	**0**	**0**
	Total	**30**	**100**
Brainstorming	Most relevant	12	40
	Relevant	17	57

	Not relevant	0	0
	No response	1	3
	Total	**30**	**100**
Modelling	Most relevant	15	50
	Relevant	10	34
	Not relevant	4	13
	No response	1	3
	Total	**30**	**100**
Role-play	Most relevant	12	40
	Relevant	15	50
	Not relevant	3	10
	No response	0	0
	Total	**0**	**100**
Question and answer	Most relevant	5	17
	Relevant	8	27
	Not relevant	16	53
	No response	1	3
Presentation	Most relevant	11	37
	Relevant	18	60
	Not relevant	1	3
	Not response	0	0
	Total	30	100
	Total	30	100
Project	Most relevant	19	63.3
	Relevant	9	30.0
	Not relevant	1	3.3
	No response	1	3.3

	Total	30	100
Investigation	Most relevant	20	66.7
	Relevant	9	30.0
	Not relevant	0	0
	No response	1	3.3
	Total	**30**	**100**

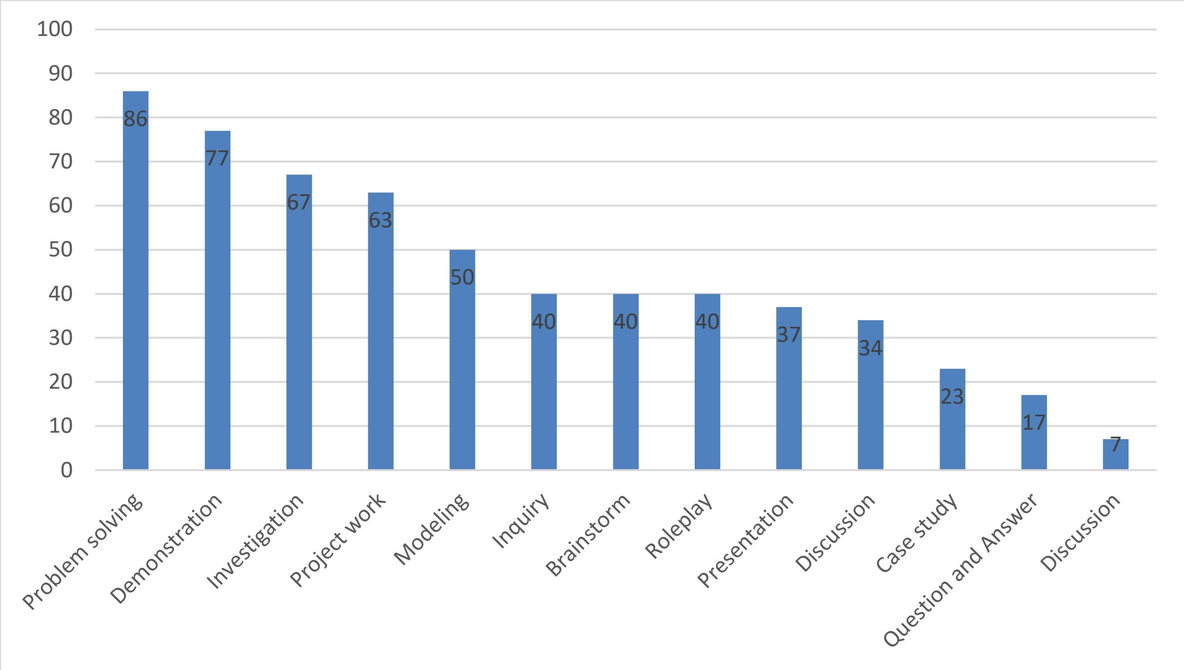


Figure 4-6:Strategies that are relevant in enhancing science learning and promoting SL

Summary of the strategies that are **relevant in enhancing science learning and promoting SL**

Most relevant

Problem solving (86%); Demonstration (77%); Investigation (67%); Project (63%); Modelling (50%); Inquiry (40%); Brainstorming (40%), Role-play (40%); Presentation (37%); Discussion (34%); Case study (23%); Simulation (13%); Question and answer (17%).

Relevant

Case study (70%); Presentation (60%); Brainstorming (53%); Discussion (53%); Simulation (50%); Role-play (50%); Inquiry (47%); Modelling (34%); Project (30%); Investigation (30%); Question and answer (27%); Lecture (23%); Demonstration (13%); Problem solving (10%).

Not relevant

Lecture (70%); Question and answer (53%); Simulation (13%); Discussion 13%); Modelling (13%); Demonstration (10%); Inquiry (10%); Role-play (10%); Case study (7%); Presentation (3%); Problem solving (3%); Project (3%); Brainstorming as well as Investigation (0).

4.7.2 Qualitative results on strategies that are relevant in enhancing science learning and SL

Table 4-33: Theme and sub-themes on strategies that are relevant in enhancing science learning and SL

Relevant strategies in enhancing science learning and promoting SL	Most relevant	Problem solving, Demonstration, Investigation, Project, Modelling.
	Relevant	Case study, Presentation , Brainstorming , Discussion
	Not Relevant	Questions and answer, Lecture,
	Technology intergration	Some educators are aware of technology intergration and its relevance in science learning and promoting SL. Others are aware but do not use technology gadgets . Technology tools are available but do not use them both the educators and learners.
	Use of Science inquiry	Some educators are aware of science inquiry relevance for science learning and promoting SL. Others are aware of certain aspects of science inquiry. Other educators are aware but they claim it is time consuming.
	Application of Predict-Observe-Explain (POE)	Educators are aware of POE and they apply it in N.S practical task. Some know the strategy , but they do not apply it due to lack of resources. Others claim they do not use the strategy because of attitudes.

Most relevant strategies

Educators are aware of the strategies that are most relevant in science learning and promoting SL. Some of their verbatim quotations are as follows:

> *The methods that are working for me and are relevant for SL in my classroom are, demonstration because learners are able to show the meaning of the concept. Investigations they use experiments to see if the theory learned is understood about forinstance, food with starch turn into a different colour, after experiment they are clear about the concept. In projects they are given a task that will last for a week or more than and it needs research skills and sometimes need hands on activities. Lastly Problem solving makes learners to think critically before coming with an answer (T2).*

> *I use the following strategies to promote science learning and SL, Demonstration, Investigations, Project, Modelling, and problem solving. I believe they promote social constructivism which allow students to participate in the lesson actively (T4 and T10).*

> *I think these two strategies are relevant; investigations, problem solving however, I do not use all the strategies because of work load, I assume demonstration can serve the purpose since it reflects demonstrating something (T1) and (T8).*

> *The strategies that are relevant to me are demonstration, problem solving, investigations, project work and modelling because they let the students participate in the lesson, not only participate they use their thinking skills and process skill to conduct experiments. But sometimes it is not easy to conduct these experiments because of shortage of resources and laboratory in our school (T3).*

Relevant strategies

Educators identified the strategies that were relevant in enhancing science learning and promoting SL. They pronounced that:

The ones that are relevant for science learning and promoting SL are simulation, presentation, case study. learners can see the simulations in the laptop and be able to present them without delay because of the lack of science materials. In the same topic they can be given a scenario to solve as a case study and all learners participate. Brainstorming can also be useful as they talk about the topic they use their thinking skills (T5).

Discussion, case study, presentation and demonstration can promote SL because learners share their ideas (T4) and (T7).

These strategies both promote interactive learning and SL and are case study, brainstorming, presentation and discussions though it is difficult to use them all since the time is not always available due to teaching many students in different classes (T9).

Not relevant

Educators mentioned the strategies that were not relevant at all in promoting both science learning and SL. They voiced out that:

Lecture is the traditional method that is not even encouraged to use as it focus more on chalk and talk and students do not participate they listen. It is the strategy that discouraged interactive learning (T7). It also inhibit the use of process skills in practical tasks (T3).

Most educators voiced out that:

Lecture method and question and answer are the strategies that do not allow students to do hands on activities. The teacher is the only one talking in the class, no critical thinking is promoted (T6) and (T9).

4.7.2.1 Technology intergration

Educators are aware of technology intergration and the importance of including technology in the teaching and learning (T1). One teacher articulated that:

Technology intergration empowers both educators and learners e.g smart phones have google, you can google certain topics to get information. Tablets are available here at school and they are meant for learners. However they are few and are not used by learners instead they are kept in the school office. Even educators when they need access they have to ask a permission first to use the tablet. We even forget that there are tablets because they are kept in the office (T1). I do intergrate technology in my teaching, my school received 500 tablets for learners, textbooks are loaded in the tablets for learners, even periodic tables for science are there so that learners can be clear. My learners also use these tablets (T3).

We do use tablets in our class, our science teacher give activities that are in the text book in the tablets, sometimes our teacher use projector in class (FG3).

When probed further concerning educator training in using the tablets, an educator responded:

Educators were trained how to use them. But they were meant for learners but educators use them on certain times. Learners are clever in technology, if they can be given a chance to use them the process of learning can be very easy. There is also a projector but it is used for analysis of results, I do not know who is actually controlling it but it is not meant for teaching and learning (T1).

If tablets are there for learners but if they are not given an opportunity to use them, technology knowledge is inhibited . Findings show that educators are also struggling to get the tablets-they are just kept in the Principa'ls office.

I use projector, laptop for teaching science and learners are not allowed to use their smart phones in school. They use them when given a task to do e.g going to www.facebook.com/siyavula in that website I refer them when I give them tasks. I also entered my learners in SAASTA Olympiad, I registered already for this year 2018 (T4). At my school we do not have technology gadgets, myself I do not have laptop (T2).

Phones are not allowed in our school and we do not have tablets like other schools, we wish we could have our own (FG2).

We do not have gadgets in our school, no technology devices we use our own gadgets. It is only the teacher uses them learners are not allowed to use phones in class (T5) and (T6). We use projectors in grade 12 only not yet in grade 9, I use my laptop when teaching (T7).

We do not use our phones to goegle information at school, we use them at home and there are no tablets available at school (FG5) and (FG7). There is a computer lab but we do, it may be used by Matric students and we are not allowed to bring our phones for internet, we use our phones at home (FG6).

When we talk about technology lets not think about gadgets only but lets think about medicines. Medicines can be used to mix to heal something. Then, if they learn it at school they can do it even at home, for an example. If you teach them about elements of periodic table. You teach them nuetralization about hydraulic acid and how it affects. There are uses of sulphur at home even at school. At home it cures ring worms. I use tablets because textbooks are already loaded there, and I use www.facebook.com/Siyavula it assist learners a lot in science (T9). I include technology approach in my teaching like make use of projectors, computers with simulations. I have my notebook with simulations, it has assisted me a lot e.g I use it for electric circuits,series, parallel, resistors, electric circuits. I normally use it in grade 9 (T10).

Our teacher use her laptop when teaching us, but we do not have tablets, our phones we use them at home only (FG10).

From the stated findings above it is clear that some educators integrate technology with resources at school, though others use their own gadgets while some do not use them at all. Some learners are able to use tablets offered by the school, others use their phones at home since phones are not allowed to be used at school.

4.7.2.2 Science inquiry

Inquiry is a process of understanding the characteristics of science through SL experiments and through tryouts and testing. Some educators understand the concepts. However, there are some parts they do not apply in class. Others are aware but they do not use the strategy and claim that it is time consuming. Science inquiry is the strategy that is very important especially for practical tasks as it involves experiments and project work among others. Therefore, it shows that an important subject that opens doors for the science field in higher education can be neglected sometimes because some educators claim that certain strategies are time consuming. Various educators shared their experiences by stating that:

> *I do not know the strategy, but I am aware of experiment under the strategy but I do not conduct practical tasks due to lack of apparatus and resources (T1).*

> *Iam aware but there are tasks that I do not use them (T5). Aware of some aspects but most of them I do not use (T3), I use only demonstrations and experiments in science inquiry, others I do not use them because I do not know them and I have never seen and heard about them even in workshops (T6) and (T8).*

When T10 was probed about giving the reasons for not using other aspects in science inquiry, the educator articulated like this:

> *I am aware of the strategy science inquiry, but Iam not using all the categories under the strategy and I don't want to blame other people I blame myself. At times I become lazy to prepare. I don't give myself enough time, so I just leave it like that. Secondly attitudes of us as educators it is about preparations, not that we do not know, it is just attitudes (T10).*

It is clear that educators use the strategy but there are challenges which they encounter in some aspects, while other educators do not attempt to apply them in class due to their negative attitude.

4.7.2.3 Application of predict-observe-explain

It is a teaching strategy that promotes the use of practical work in science. Predictions are very significant and must be accompanied by logical reasoning. Educators came with different opinions concerning the strategy. Some said that they used the method and others said that they were not using it because of the lack of apparatus in their schools. Educators expressed themselves:

> *I know the strategy but I don't use it because of attittudes. I need thorough preparation and it is time consuming. The problem we have like myself Iam teaching grade 12 physics, grade 11 physics, grade 10 physics, grade 11 life science, grade 8 natural science and grade 9 natural science. Attitudes are caused by the overload for different grades. Preparation for all the grades is challenging. I concentrate more on grade 12 because they are moving out , it is not easy to concentrate on lower classes, although we know background is important but passrate is important(T10).*

> *Not yet done practical tasks this year (FG10) and (FG8).*

Clearly it shows that some educators experience serious challenges in teaching N.S in grade 9. Other educators shared their experiences as follows:

> *I am aware of the strategy-it is the one I believe that predictions and observations are very important before an individual conducts an experiment. We need to promote that as educators. Whenever you demonstrate learners must predict what is going to happen.It also relate with what they learn from science in real life. I always say the best drivers are the science people because they can measure as they are the people with skills. Whenever you look at something as a science student you must look at it critically, you don't just look like any other person (T9).*

> *Aware of the strategy and I apply it in class they predict first it is callled hypotheses and then they observe and do the experiments and record the data (T3), (T4), and (T5). Not yet applied the strategy (T8).*

We do a lot of practical work, two weeks back we made planets sing artificial dough (FG3). Already done experiments in the laboratory, our teacher conduct the experiment first and we observe after we follow, however our resources are few so we take turns (FG4). We are given a task to bring carrots, potatoes, we are going to check the presence of starch using iodine solution (FG5).

Findings show that some educators are aware of the strategy. However, others still have challenges and theorize. Practically it may not be easy since they lack resources but negative attitudes need urgent intervention.

4.7.3 Summary of main findings on the strategies that are relevant in enhancing science learning and SL

Responses showed that educators identified most relevant, relevant and not relevant strategies. They are aware of technology intergration but some of them do not have access in school to gadgets. Regarding science inquiry, most educators knew some aspects but others did not understand the advantages of applying the strategy. About POE they complain about lack of resources and time constraints. The table below furnishes the main findings regarding strategies that enhance science learning and SL.

Table 4-34: Summary of the findings

Findings (Quantitative data)	Findings (Qualitative)
The educators identified these as being most relevant in their subject with rates of agreement of 86% and 77% respectively. Relevant identified as 70% and 60%. Not relevant are: 70% and 53%	Most relevant:Educators mentioned the strategies as: Problem solving, demonstration, investigation, project and modelling. Relevant: Case study, presentation, brainstorming and discussion are the relevant strategies recognised as relevent by the educators. Not relevant: lecture, question and answer were mostly selected by educators as the strategies that do not promote SL. Educators are aware of technology intergration and some do integrate when using science strategies. Some educators are aware but do not have access to technology tools (kept in the office). Others are aware but do not use technology gadgets, they are used in higher grades.
Science inquiry methods were also selected as the least relevant methods when administering NS classes. Science inquiry consists of simulations and demonstrations. Most relevant at 77%, project work relevant at 50% and Simulation relevant at 50% rates.	Educators confirmed that they are aware of science inquiry but do not know the usefulness of the strategy. Others claim it is time consuming. Some aware of certain aspects , other aspects never heard or seen them.
The POE strategies also include some strategies from the above sections. project work and investigations are examples. The admission of the relevance of these methods in the educators work was high as indicated by the above rates.	Educators stressed that they know the POE strategy but they don't use it because of attittudes. Other educators do not use the strategy due to lack of resources. Some of the educators claim that they are aware of the POE strategy and they apply it in N.S practical task.

4.7.4 Interpreting summary of the findings

In general, the respondents showed that they understood the relevance and importance of the different teaching strategies when delivering NS classes. The table shows that not all the respondents admitted to practically utilising the approaches for various reasons. The evidence shows that the educators acknowledged the relevance with high levels of consensus. Key findings revealed that the most relevant strategies were: Problem solving, demonstration, investigation, project and modelling. Relevant strategies are case study, presentation, brainstorming and discussion. Not relevant for enhancing science learning and promoting science literacy were lecture as well as question and answer. These were mostly selected by educators.

Educators are aware of technology integration and some do integrate when teaching science using science strategies while others are aware but do not have access of technology tools as they are being kept in the school office. Educators confirmed that they were aware of science inquiry. However, they did not understand some of the aspects and the strategy was considered as time consuming. Educators also stated that they knew the POE strategy but some did not use it due to lack of resources. Some harboured negative attitudes.

4.8 4.7 Results on how educators assess science learning and promoting SL.

Educators came up with various experiences concerning the concept assessment, however they all highlighted learner performance.

4.8.1 Quantitative results on how educators assess science learning and promoting SL

Table 4-35: Responses on how educators assess SL

Strategies	**Responses**	**Frequency**	**Percentage%**
Principles of assessment	Agree	21	70.0
	Neutral	9	30.0
	Disagree	0	0
	No response	0	0
	Total	**30**	**100**
Align with cognitive domain	Agree	23	76.7
	Neutral	4	13.3
	Disagree	0	0
	No response	3	10.0
	Total	**30**	**100**
Tests	Agree	29	96.7
	Neutral	1	3.3

	Disagree	0	0
	No response	0	0
	Total	**30**	**100**
Assignments	Agree	30	100.0
	Neutral	0	0
	Disagree	0	0
	No response	0	0
	Total	**30**	**100**
Presentations	Agree	24	80.0
	Neutral	4	13.3
	Disagree	1	3.3
	No response	1	3.3
	Total	**30**	**100**
Quiz	Agree	13	43.3
	Neutral	9	30.0
	Disagree	6	20.0
	No response	2	6.7
	Total	**30**	**100**
Projects	Agree	27	90.0
	Neutral	2	6.7
	Disagree	1	3.3
	No response	0	0
	Total	**30**	**100**
Experiments	Agree	28	93.3
	Neutral	1	3.3
	Disagree	1	3.3
	No response	0	0

	Total	**30**	**100**
Debates	Agree	13	43.3
	Neutral	10	33.3
	Disagree	4	13.3
	No response	3	10.0
	Total	**30**	**100**
Examinations	Agree	21	70.0
	Neutral	5	16.7
	Disagree	4	13.3
	No response	0	0
	Total	**30**	**100**

Data illustrates how educators assess SL. The responses were as follows: agree, neutral, disagree and no response.

Agree

Assignment 100%; Tests 97%; Experiments 93%; Projects 90%; Presentation 80%; Align with cognitive domains 77%; each among Principles of assessment and Examinations 70%; Quiz 43,3% and Debates 43,3%.

Neutral

Debates 33, 3%; each among Principles of assessment and Quiz 30%; Examinations 17%; each among Align with cognitive domain, Presentation and Debates 13%; Projects 7%; Experiments 3, 3% and Tests 3%.

Disagree

Quiz 20%; Debates 13,3%; Examinations 13%; each among Presentation and Experiments 3,3%; Projects 3%; each among Principles of assessment, Align with cognitive domain, Tests and assignments 0%.

No response

Each among Align with cognitive domain and Debates 10%; Quiz 7%; Presentation 3,3%; each among Principles of assessment, Tests, Assignments, Projects, Experiments and Examinations 0%.

The majority of the respondents at 100% agreed that they adhere to the use of assignments as assessment, tests at 97% and experiments at 93%. It was agreed that practical and hands-on approaches were some of the best strategies when enhancing SL. Similarly, there can be no sufficient and proper sciences curriculum without experiments. Consequently, assessment of project work should be a vital tool. When enquired, 90% of respondents agreed that it was a useful and effective method of assessment while one was neutral and another disagreed. For presentations it was 80% who agreed. When questioned on whether the educators align their assessments to the cognitive domains, 76.7% confirmed while the remaining 13.3% were indifferent. Examinations are an inescapable part of the South African curriculum and as such it was expected that the approval rate would be relatively high. For principles of assessment it was 70% who agreed. 70% of the respondents also agreed that examinations were highly useful in assessing learners' performances.

Neutral participants towards examinations were 5 (16.7%) while 4 (13.3%) disagreed that examination was an assessment tool. It clearly illustrates that rural schools do follow the policy CAPS DBE (2011), which highlights that all forms of assessment involve generating and collecting evidence of achievement and evaluating this evidence using these different forms. Furthermore, CAPS mentions that formal tasks include marks that need to be recorded and these are exams, tests and practical tasks or investigations. This outcome although expected, particularly because of the remoteness of the schools, is of concern as there is no 100% adherence to the principles of assessment. Quizzes are not a relatively common practice for assessment in rural schools in South Africa and as such, the agreement rate declined: 43.3% of the respondents agreed that quizzes were useful, 30% were neutral, 20% disagreed and two did not respond. Debates were generally not considered as important. The approval rates naturally declined 43.3% of the respondents agreed that debates were useful and for effective assessment tools, 33.3% were neutral, 13.3% disagreed and the remaining 10% did not respond to the question.

4.8.2 Qualitative results on how educators assess science learning and promoting SL

Educators do understand assessment and they apply it in formal and informal tasks. The study sought to find out if the assessment strategies were used to promote science learning and SL. The researcher engaged them more using the following themes; educators' knowledge of assessment, application of assessment and effective ways of assessing both content and practical.

Table 4-36: Theme and sub-themes on how educators assess science learning and promoting SL

Assessment	Educators knowledge of assessment	Most educators have knowledge about assessment.
	Application of assessment	Align assessment with cognitive domain. Assessing using various information. Use of SL skills when assessing.
	Effective ways of assessing both content and practical	Use of practical and theory(test). Use of demonstration and presentations using rubric. Use of group work: theory converted to practical.

4.8.2.1 Educators knowledge of assessment

Findings revealed that educators have a common understanding of assessment. Their views were as follows:

> *In assessment you assess what you have taught, you want to know if learners understand. For instance I give learners classwork, class test. Assignments, case study (T2).*
>
> *Before you teach you have objectives you want to achieve, in an assessment you want to know if you achieved the objectives. I use the following tasks when assessing, assignments, test, research, projects (T3). Ensuring if the*

knowledge you want to impact, do learners understand it, getting feedback on what has been taught (T6) and (T4).

One educator expressed differently from others by highlighting that:

> *Firstly when you* are *a science educator, bear in mind the SL skills. When you assess, assess the SL skills more than the knowledge e.g. learners can predict, measure, they can also identify and classify things (T9). When talking about assessment I think of classwork, homework, practical or test. Assessment also for myself, my HOD checking my assessment, writing down the observations, getting feedback, getting assisted or me assisting learners. Then changing strategy if assessment or feedback is not what I expect (T10)*
>
> *Our teacher give us assessment like test, classwork and she provide feedback on the written assessment and we follow by doing corrections (FG10). We write tests, class work and do projects and our teacher explains the feedback after the task (FG3). We do classwork's and tests not yet done other tasks (FG5).*

It is clear that educators understand assessment and types of assessment though they never mentioned anything about formative and summative assessment.

4.8.2.2 Application of assessment

Assessment should be planned against the content (concepts and skills) and specific aims for Natural Sciences. In both informal and formal assessment it is important to ensure that both are used in the course of a school year (DBE, 2011). DBE (2011) further mention that assessments in natural sciences must cater for a range of cognitive levels and abilities of learners within this context. Educators' responses were similar with only a few different views. Educators voiced out that:

> *In my school we follow the policy, we take the assessment to the HOD i.e. checking levels of questioning like higher order and lower order. Questions must vary to develop the skills differently. They must have time to recall something, time to relate for example this term we deal with living organisms starting from cells, tissues, the organs, organisms and systems. Learners must be able to relate digestive with circulatory system. Providing learners with a picture of animal cell and plant cell and let the learner to brainstorm about the*

picture not necessarily differentiate but to apply their knowledge about the picture (T9).

There are aspects that I follow when assessing my learners, For instance I do not give a test for the sake of giving a test. Firstly when I teach there are objectives I want to achieve, I would find out if they are achieved through a task I gave my learners. I consult the HOD for checking good principles of assessment (T10).

Some of the educators mentioned that they followed the cognitive domain when assessing. When probed and requested for examples of questions, they gave me lower order questions, e.g.,

To be honest sometimes I do align and sometimes I do not align questions with cognitive domains, I use questions like what, list (T6). I take my task to the HOD for moderation, she is the one to decide if the task is done appropriately (T5).

Other educators claimed to follow the levels of assessment as specified by CAPS document and they even gave examples. Some of the examples were as follows:

*I use higher order and lower order questions e.g. I give my learners a diagram with photosynthesis process, then they must analyse what is happening in the diagram and I allocate marks using rubric (T1). When I assess I make it a point that all the cognitive levels of assessment are covered in the assessm*ent, not only the remembering questions, synthesise must be included (T4).

Findings revealed that most educators understand the application of assessment but a few needed assistance.

4.8.2.3 Effective ways of assessing both content and practical

Both the content and practical need to be assessed in science learning and in promoting SL. The focus was to find out how educators assessed both content and practical. The assessment may be based on the end-result of the activity (the product), or the carrying-out of the activity (the process), or a combination of both. Assessment tools of projects could be a combination of rubric, memorandum, checklist, etc. (DBE, 2011). Content, concepts and skills across all the topics, including knowledge of investigations and some skills associated with practical work must be assessed in the written exams (DBE, 2011). Participants came with various options while others were silent and remained confused about how to assess both and they voiced out that:

> *As a science educator it is a must to have a practical because science is a practical subject. So if they apply with their knowledge they will understand more and get deeper understanding. Theory is assessed because you need recording (T9). Practice makes perfect, we have a lot of theory and it must be put in practice to achieve (assessing both) (T10). I think there are so many ways that can be used to assess both content and practical. Some can use practical e.g. do experiments then combine them both at the bottom there must questions whereby learners can go and research more (T4).*

> *Assessing them both content and practical e.g. in Electricity they will do simple circuit parallel and series in practical. For content they will give advantages and disadvantages of using electricity (T3). In practical assessment, learners go to the lab to do experiments using information (theory). In theory learners must write a test. For practical, observations must be done, experiment must be conducted and allocation of marks should be rubric (T8).*

Findings revealed that only a few educators were able to assess both and others were silent.

4.8.2.4 Main findings on how educators assess for science learning and promoting SL

Table 4-37: Summary of the findings

Findings (Quantitative data)	Findings (Qualitative data)
70% of the educators admitted to adhering to the principles of assessment while the remaining 30% were either indifferent or did not respond.	Educators confirmed that they did have knowledge about assessment.

76.7% of the respondents confirmed that they aligned assessment with the cognitive domains while the remaining 23.3% were indifferent towards this.	Concerning application of assessment educators do align assessment using cognitive domains, others do not. Some use various information for assessment
Assignments and tests proved to be the most commonly approved method of assessment for the educators with 100% and 96.7% respectively. Practical work had an outcome of 80%.	Concerning effective ways of assessing both practical and theory, they confirmed that they use practical and theory for test. Some use group work to conduct practical activities using rubric.

4.8.2.5 Interpreting the summary of findings

The table above shows that the educators do know about the principles and application of assessment methods. Both the quantitative and qualitative aspects show that it is not in all cases that this knowledge is transferred into practical application by the educators. Some are either unwilling or indifferent in their assessment practises and thus there was no 100% consensus in terms of adhering to principles and cognitive domain. The evidence from both sides shows that the educators use the most common and easiest assessment methods of tests and assignments in their classes. Key findings were: educators confirmed that they had knowledge about assessment; they aligned assessment using cognitive domains; some used other forms of assessment while some did not. Concerning effective ways of assessing both practical and theory, they confirmed that they used practical and theory for test.

Edward (2013) clarifies the importance of assessment and also emphasizes that science educators must use high quality assessment process when assessing learners. The CAPS document also stresses the importance of assessment (DBE, 2011).

4.9 Results on Lesson observations

Lesson observations allow one to directly see what people do without having to rely on what they say they do. Lesson observations comprise of observation schedule with key aspects which the researcher wanted to see. It was aligned with research questions.

Table 4-38: Lesson Observation

Lesson Introduction	Some educators introduced the lesson starting with prior knowledge and continued with the new topic. Others started with things to expect in the lesson, e.g today we are going to learn about respiratory system. One teacher out of ten educators approached the lesson with a story telling. The story was about the new lesson, each student was playing a role.
Teacher Activities	Some of the activities were promoting science learning and SL e.g they were demonstrating . Others were using more of these strategies; question and answer, lecture method and text book method. These strategies were dominating.
Learner Activities	Learners were responding by answering the questions.Some learners were in groups and answered questions at the same time as the whole class. In two schools , learners were doing activities using demonstrations.
Relevant strategies that promote science learning and SL	ICT was used by few educators. Demonstration
Teaching and Learning materials	Chalkboard and textbook was dominating.Few used laptops
Educators Pedagogical knowledge (PCK)	Many educators were knowledgeable about the N.S content but some lacked content knowledge. Interactive approach was promoted by some educators.
Application of experiments (Practical task) POE	Few applied POE in the lesson observation.
Assessment	They used classworks, worksheets and assignments. One school showcased the model of the planets as the project that was given to learners.
Technology intergration	Few used laptops Others were using chalkboard and textbook
Science Inquiry application	Some managed to use a few aspects of science inquiry e.g demonstration and projectwork
Achievement of learning objectives	Most educators achieved objectives of the lesson

Key findings revealed that when educators started a lesson they approached it diffferently. Some started with prior knowledge, others used the traditional method of telling students about the topic they would learn and yet others used their creativity. Concerning educator activities, question and answer and lecture method dominated the lesson. In learner activities some of the learners answered to the questions posed in groups while others were doing activities using demonstrations. ICT was used by some of the educators but demonstration was mostly used. Chalkboard and textbook dominated, but a few used laptops. Concerning educators' pedagogical content knowledge (PCK), most of the educators were quite knowledgeable about science content. A few had challenges with content knowledge, perhaps they taught the subject they did not specialised in and others were new in the field. An interactive approach was applied by many educators. Few conducted experiments in their lessons. Assessment was mostly done by educators through classworks, worksheets and assignments where students were expected to use their research skills. Projects were also done by some of the schools- it was shown by one school which showcased the model of the planets. Concerning technology intergration, some were intergrating their lesson with technology while others were struggling because of different challenges. Some educators did apply science inquiry but they rarely used demonstration and project work. Lesson objectives were mostly achieved.

CHAPTER FIVE

DISCUSSION OF FINDINGS, IMPLICATIONS, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction

The study examined educator’s strategies to promote science learning and SL among grade 9 learners in a rural district in the Eastern Cape Province in South Africa. The focus was on natural science educators and learners. In this section the research findings are discussed thematically in a broader context aligned with sub research questions from both quantitative and qualitative results. The themes were: strategies educators use to teach natural science curriculum, strengths and weaknesses of these strategies, how educators were supported for science learning and promotion of SL, strategies that were relevant in enhancing science learning and promotion of SL and how educators assessed science learning and promotion of SL.

5.2 Strategies educators use to teach natural science curriculum

The triangulated data showed general consensus that educators use various strategies to teach natural science.

5.2.1 Strategies employed by educators

The science educators confirmed that they knew many strategies and they applied them in class, for example, discussion, lecture, problem solving, demonstration, and presentations. The strategies mentioned by the educators belong to macro- and micro-strategies as observed by Akdeniz (2016). Saskatchewan Education (1991) emphasizes the advantages of interactive learning as promoting students’ interest and curiosity, often encouraging them to make other choices to solve difficulties. Aji & Budiyono (2018) explain the strategy as one to attain a certain goal.

Educators also identified lecture as the strategy that is most employed in the classroom. The study found that most educators use this method, they support it as it is the one that assists in the process of science learning. Other educators highlighted that the method is good in relaying the information especially the complicated concepts. The findings of the current study are consistent with those of Achimugu (2018) who noted that the method was cost effective and suited schools where resources were scarce.

5.2.2 Promotion of constructivist approach

On promoting constructivism, the educators' responses were on investigations, presentations, question and answer, demonstrations, group work and project. These strategies promote constructivism as they are interactive. The present findings seem to be consistent with other research which found out that the strategies generate interest in learners and promote active engagement (Daluba, 2013; Achimugu, 2018).

5.2.3 Benefits of incorporating educator strategies in the natural science teaching

Data show that educators understood most of the strategies. Concerning the benefits of incorporating the strategies in science teaching participants revealed that these strategies promoted hands-on experiences, students were able to construct knowledge, develop research skills and create confidence, promote thinking skills and promote group work. Bruner's theory, ''discovery of learning'' encourages active engagement, promotes motivation and autonomy, responsibility, independence, creativity and problem solving skills (Bruner, 1960). Ode (2014) confirms that in demonstration students are able to identify and come up with real questions to include in learning and involves critical thinking in the process.

OECD (2016) emphasizes that most common teaching strategies used today are viewed as active learning, cognitive activation and educator directed instructions and they are important as they engage learners more in the lesson. Furthermore, the discussion and group work stimulate higher order skills (OECD, 2016). Aji and Budiyono (2018) explain the model that allows active learning as Contextual Teaching and Learning (CTL), a learning concept which helps educators compare learning materials with learners' real-world situation, and encourages learners to relate their knowledge and apply it in their daily life. Data show that learning is mostly conducted actively, creatively and productively, emphasizing the importance of cooperation i.e. learning to ask, to inquire and to work together. These are in agreement with what researchers such as Aji and Budiyono (2018) alluded to.

5.3 Strengths and Weaknesses of the strategies

This research discovered that educators considered demonstration, investigation, projects, question and answer and role-play as strategies that allowed active engagement among learners. Educators emphasised that these strategies boosted learners' confidence, promoted interaction, enhanced critical thinking, promoted sharing of ideas and made learners think beyond. These findings corroborate with those of Zajkov and Mitrevski (2012), Daluba (2013), Sumarni (2013) and Aji and Budiyono (2018).

Benefits of applying active engagement strategies as pointed out by educators were: promoting science learning and SL, developing confidence, enhancing critical thinking and sharing of ideas. Bantwini (2017) notes that to accommodate every learner, educators should explore various teaching approaches that can benefit different learners. Literature highlight that active participation of learners gives more meaningful and effective learning (Mandor, 2002 & Ibe, 2004).

Findings reveal that educators encountered challenges in active engagement such as some strategies being time consuming, learners relying on others and becoming passive at times, all members of the group not participating when given a problem, active learners dominating the less active and low ability students depending on the educator for all the information. These are confirmatory to those observed by (Youssef & Mohammed, 2016).

Strategies that promoted higher order thinking were identified as investigations, case study, discussions and problem solving. Benefits of higher order thinking as mentioned by educators were that they promoted thinking skills, encouraged learner participation,enhanced research skills, fostered deep thinking and helped in the transferrability of skills. There are similarities between the responses expressed by the educators in this study and those described by Got & Duggan (1996), Yacin, Mustapha & Zaharim (2009), Keller (2016) and Aji & Budiyono (2018) and as such are confirmatory. Concerning investigation the aim is to offer students opportunities to use concepts, cognitive processes and skills to solve problems (Got & Duggan, 1996: 26). Keller (2016) states that case studies are one of the top methods to use in the classroom as they allowed interaction in a meaningful way and strengthened problem solving skills. Case studies open opportunity for students to use research skills for a given scenario and ability to solve the problem and to come up with the evidence. Case studies also promote higher order thinking. Aji and Budiyono (2018) describe discussion method as a way of managing learning process by presenting the material through problem-solving or systems analysis of technology product whose solution is very open. In discussion, students work in groups whereby they share ideas and work in groups. Aji and Budiyono (2018) states that problem solving is a technique that provides training and ability to solve problem from simple to complex.

PBL helps students develop real-world skills such as the ability to work well with others, make decisions and take the initiative and face complex problem solving, communication, and self-management (Yacin, Mustapha, & Zaharim, 2009).Although benefits have been identified there are also challenges of higher order thinking which educators mentioned, viz: plagiarism, lack of resources in the learning process hindering learning, promotion of memorisation and some learners relying on others. A possible explanation for this might be that CAPS (DBE, 2011) emphasizes the use of resources when teaching sciences. Therefore, lack of teaching resources can be a major factor impeding curriculum implementation as observed by Phasha, et al. (2016). Educators were also able to identify the weaknesses of lecture as educator-centred, promoting chalk and talk and having no interactive learning as reported by Achimugu (2018).

5.4 Educator support for science learning and promoting SL

It was the aim of the study to find out how educators were supported for science learning and promoting SL. Regarding support, educators came with different experiences-majority of educators confirmed that workshops were available and they were attending. Few educators never attended and some voiced out that the workshops they attended were not fruitful. The majority of educators confirmed that they were benefiting from the workshops. Literature reveals that the poor academic achievement of school learners has forced the government to take a number of further steps to advance the quality of schooling in South Africa (Phasha, Bipath, & Beckmann, 2016).

The workshops are playing a role in enhancing the quality of schooling. Nkambule & Amsterdam (2018) considers educator support as mentoring, coaching, professional development and feedback upon lesson observations. Collaborative support between educators and DoE is advantageous in teaching and learning, it is confirmed by Adamson, Santau and Lee (2013) who mention that engaging educators more in the learning process can make a difference and it can also be a part of ongoing professional development. The study also revealed that educators assist each other and Heads of Department too are playing a role. With regard to the above, when educators assist each other, they are able to share information and are developing themselves professionally.

Another finding was science educators acknowledging the support provided by DoE offficials. The majority of educators revealed that they did receive support from district officials in the form of school visits to support them in content gap, mentoring (especially to the new science educators), assisting with practical work i.e conducting experiments, doing follow up on tasks needed to be done quarterly and content coverage. Literature illustrates that education districts and circuit offices are required to conduct “school visits, classroom observation, consultation, cluster meetings, suitable feedback reports and other means; providing an enabling environment and organising provision and support for the professional development of educators” (National Education Evaluation & Development Unit, 2013:15). The statement above is also supported by Department of Education (DoE, 2008:22) emphasizing that education district officials are supposed to visit all schools within the district at least once per term, with numerous visits to schools needing stronger support in monitoring and guidance as well as assist schools to advance their performance and work towards the agreed objectives.

Although the Province is giving support to educators, some educators complained about lack of support from the Province. TRAC SA in partnership with Eastern Cape Department of Education (ECDoE) is dedicated to giving support to selected Eastern Cape schools especially in science (Press reader Go & Express, 2018).

Furthermore, Eastern Cape Department of Education (ECDOE) embarked on the 2018 Educator Development Programme in collaboration with the National Education Collaboration Trust (NECT) for educators of Grades 1-9 in science and other three subjects (Curriculum Instruction G03/2017). Definitely, the Province is giving support to some extent and they also work in partnership with NGOs. Another key finding concerning support was non-governmental bodies (NGOs) giving science educator support. Some educators confirmed that they had received support from NGOs but some disputed it. A programme called Technology Research Activity Centre (TRAC SA) had an agreement with Eskom to assist science, mathematics and technology education in schools and also partner with Eastern Cape Department of Education (ECDoE) (Gosa, 2018). Gosa (2018) explains that Eskom invests in communities where there is Eskom infra-structure, and then assists government by providing support in improving access to quality education. The report further mentions that Eskom's aim is to increase intake into science and engineering for future skills needs. Another NGO that assists educators in science is National Education Collaboration Trust (NECT) in collaboration with Eastern Cape Department of Education (ECDOE). NECT and ECDoE embarked on a programme, 2018 Educator Development Programme, which is focusing more on the four key subjects and science is amongst them.

The ECDOE-NECT programme provides practice-based support for educators to improve the quality of teaching science and other three subjects (Curriculum Instruction G03/2017). The programme supports educators to complete the curriculum at the correct pace and grade level using a Tracker (Curriculum Instruction G03/2017). Educators during interviews referred to the 'tracker'. A tracker consists of CAPS concepts and activities, weeks with lesson A or B included, topics from CAPS policy document with page numbers and a date to complete the lesson.

Other structures which are giving support are the awards given to educators for their hard work, cluster support, SAASTA support and science expos. DBE is hosting teaching awards every year to motivate educators. They start competing at provincial level and the winners compete for national awards. Educators mentioned that awards created confidence when teaching the subject and encouraged additional effort in teaching. Teaching awards are used to motivate and support educators, hence in their objectives they put a focus on identifying and promoting excellence in teaching performance. Cluster support is playing a role in supporting science educators DBE (2018). According to Jita and Mokhele (2014) clusters enhance educator's content knowledge and pedagogical content knowledge. According to educators they benefit from cluster, for instance, educators participate more directly, and do common planning like setting common assessment tasks and doing team teaching in different schools (Jita et al. 2014).

SAASTA is a programme that supports educators to teach science effectively, prepare learners for the world of work and aim to promote SL among the youth by nurturing young people's talent for science, engineering and technology related careers (SAASTA, 2016). Data showed that educators received support from SAASTA. Science expos were also identified by educators as a programme that supported both educators and students in science. Department of Science and Technology (DST) supports science through Eskom Expo for young scientists and promotes science for fair events. Furthermore science fair events are projects that are educational and they contribute to pedagogical content knowledge (Mbowane et al. 2017). All these structures have similar goals of enhancing science education in the Eastern Cape Province in South Africa.

The study found that despite educators receiving support, they encounter challenges that need urgent intervention from ECDoE, district officials and other stakeholders. Emergency intervention mentioned by educators were resources for science to conduct practical tasks and empowerment for content coverage through workshops. Resources were indeed a challenge and educators complained about them. To effectively teach, science educators must not only master science content, but they must also be familiar with how learners learn science (Adamson, Santau and Lee, 2013). Mudulia (2012) notes that for effective science teaching, textbooks, revision books, laboratory chemicals and equipment should be readily available. In addition, Mtsi and Maphosa (2016) highlight that poor infrastructure and limited resources can have negative effects on science teaching and learning.

Some educators also mentioned that they needed training in science since it was not their specialist subject and they were given the subject because of the shortage of educators. Adamson et al. (2013) highlight that engaging educators more in the learning process can make a difference and it can also be a part of ongoing professional development. In addition, Mestry, Hendricks and Bisschoff (2009) mention that improving the quality of educators has a constructive influence on the quality of learners' achievement, and the overall performance in the education system. It means when educators get training, quality in education can be improved. Some teachers mentioned that they were unqualified to teach science. Kola (2013) as well as Ogunniyi and Rollnick (2015) highlight the problem of being unqualified to teach science in schools in Africa and how this negatively affected quality in science teaching and learning. Therefore, the above researchers emphasize that when an educator lacks content knowledge, learners are negatively affected and promotion of SL will be inhibited. Ofsted (2013:10) notes that youngsters "learnt best when they could see how the science they were studying linked to real world experiences". Educators unqualified in science cannot assist on this. Confederation of British Industry (CBI) in their 2015 report, emphasised how learning science must be addressed at the primary phase of education if schools were to nurture science literate citizens for the future.

5.4.1 Strategies that are relevant in promoting science learning and SL

It emerged from the study that educators were aware of the strategies that are most relevant, relevant and not relevant in enhancing science learning and promoting SL. Those that were identified as most relevant were problem solving, demonstration, investigation, project and modelling. The ones that were identified as relevant were case study, presentation, brainstorming, discussion. The ones that they considered not relevant were question and answer and lecture. The most relevant strategies belong to active engagement strategies and higher order thinking which promoted constructivism and PCK.

On technology integration, use of science inquiry and application of predict-observe-explain strategies, the study found that educators were aware of technology intergration. Some of the educators use technology to drive science lessons, while others rely only on textbook and chalkboard. Ibe-Basse (2011) defines ICT as a critical tool for preparing and educating learners with the required skills for the global work place. Butler et al. (2013: 8) state that "ICTs support an enquiry process and enable the learners to work on solving complex real world problems by engaging in collaborative project - based learning activities that go beyond classroom". The use of

ICT in teaching, learning and assessment can enhance the learning experiences of all learners (Digital Strategy for Schools ,2013). In order to equip learners for the digital transformations during this era of the 4th industrial revolution, the use of ICT needs to be enhanced and educators need to be empowered for using ICT. Some educators were aware of the need but did not have access to technology tools as the management keeps them in the school's office. Schools must make every effort to ensure that the vital equipment is provided and educators should be stimulated to improvise (DBE, 2011). Another finding was that some educators were aware of science inquiry but did not know the usefulness of the strategy while some claimed that it was time consuming. Science inquiry is the umbrella strategy with other aspects under the strategy which are simulation, experiment, demonstration, project work and field work. If educators do not mix these, learners will encounter challenges in understanding science in all dimensions.

The study further found that educators were aware of predict-observe-explain (POE) strategy and they applied it in N.S practical task. It requires tasks to be carried out first and helps to uncover the individual learner's predictions and his/her reasons for making this a specific event (Sreerekha, Arunraj & Sankar, 2016). The strategy uses the process skills mentioned in the CAPS document, whereby learners are expected to identify the problem, form hypothesis, design an experiment, observe and make inferences about the observations. Some educators know the strategy, but they do not apply it due to lack of resources and others claim that they do not use the strategy because of their own negative attitudes.

5.4.2 Educator assessment for science learning and promoting SL

Data show that educators have knowledge about assessment. For example, some mentioned that "in an assessment you assess what you have taught, you want to find out if learners understand". Others concurred by statements similar to "when assessing you want to ensure if the knowledge you want to impart, learners understand it and getting feedback on what has been taught". Concerning assessment, the CAPS document stresses that assessment is a continuous and planned process of identifying, gathering, interpreting and diagnosing information about the performance of learners (DBE, 2011).

It emerged from both interviews and questionnaires that while some educators aligned assessment with cognitive domains, others did not. Yet again, others take the assessment to the HoD for moderation. With regard to the above, Bloom's taxonomy (1956) comes with the framework that emphasizes thinking and the aim is to promote higher forms of thinking in education such as analysing, synthesis and evaluating rather than just teaching learners to remember facts (rote learning). Bloom (1956) states that learning is divided into three domains- cognitive (knowledge), affective (attitude) and psychomotor (skills). Cognitive domains are listed in six major categories starting from the simplest thinking behaviour to the most complex (knowledge, comprehension, application, analysis, synthesis and evaluation). Therefore, the domains suggest that educators when assessing they must use a variety of questions that will allow learners to respond based on the six major categories. These categories give an opportunity even to those learners with cognitive challenges to participate. CAPS document also emphasizes the use of cognitive skills when assessing, for example: to assess knowledge of science use lower order questions like state, list, define and to assess comprehension of science and application of SL knowledge use middle order questions like explain, compare, predict and apply. While evaluating, analysing and synthesising SL knowledge higher order questions like suggest a reason or interpret can be used (DBE, 2011). So, it is significant that educators combine the questions to cater for all the different types of learners when assessing, and before submitting to the HoD, each educator needs to evaluate himself/herself first to confirm whether these levels of cognitive skills are included in the assessment.

Educators reported that they aligned their assessment with the principles of assessment and also followed procedures at school for assessment. On effective ways of assessing both practical and theory, educators reported that they used practical and theory for tests. Assessing practicals is important in science. CAPS policy document emphasizes that when carrying out practical tasks learners are required to demonstrate their skills proficiently. When learners use materials and equipment to create, produce or investigate something, educators must observe learners. Any practical task should provide opportunities for learners to demonstrate several different skills (DBE, 2011). CAPS document emphasises that when doing investigations it is important to use appropriate apparatus and equipment, collect data by observing and comparing, measuring and estimating, sequencing, or sorting and classifying. Sometimes an investigation has to be repeated to verify the results (DBE, 2011).

CAPS stipulates that all forms of assessment involve creating and gathering proof of achievement and the evaluation of this evidence and its use helps to understand and assist the learner's development in the teaching process (DBE, 2011). Murphy (2009) suggests that assessment measures student's achievement and highlights that a well-designed assessment can have a positive impact on learning. Edwards (2013) clarifies the importance of assessment and emphasizes that science educators must use high quality assessment process when assessing learners. Furthermore, educators are required to develop skills that will assist them in designing assessment tasks that will value prior learning and learners' abilities (Edwards, 2013).

5.4.3 Main findings concerning observations

Some educators responded positively while others did so negatively. Some educators' lesson presentations contradicted with their interview session; what they mentioned during the interview session was not applied in the lessons. Gathering of prior knowledge was done before the lesson began. Once the educator starts with new knowledge and links it with what the learners already know using active engagement strategy learners should find the lesson interesting enough to make them concentrate more and eager to learn. Literature shows that Prior knowledge strongly influences positive thinking and understanding of texts and diagrams, including the ability to move flexibly between texts and diagrams (Mathai & Ramadas, 2009). In addition, those with high prior knowledge pay more attention to and are faster in conducting messages compared with low prior knowledge students (Liu & Hou, 2011; van Gog & Scheiter, 2010). Subsequently, low prior knowledge students change more frequently between macroscopic and molecular representations, suggesting that these students experience difficulty as they coordinate representations (Liu & Hou, 2011; van Gog & Scheiter, 2010).

Another finding was that learners were responding as a class or as groups when questions were posed. Constructivism theory promotes student engagement and allows students to work as teams responding actively through making use of higher order thinking skills. It was found that some of the educators integrated technology, practised POE and applied science inquiry. Therefore, the relevant strategies that the present researcher was focusing on during the lesson observations were applied by educators but not maximally. Such observations indicate that there is a need for development of educators for application of science inquiry, POE and technology intergration in order to meet the 21st century demands.

5.5 Chapter summary

The chapter presented, analysed and discussed the findings from both quantitative and qualitative aspects. The section was discussed thematically linking to the research questions and focusing on examining educator's strategies for promoting science learning and SL.

5.6 Summary, conclusions and recommendations

5.6.1 Introduction

The previous section presented and analysed quantitative and qualitative findings separately and triangulated during interpretation to establish convergence. The current literature was used to support the findings and linked with the theories that informed the study. The current section presents a summary of the findings,recommendations and suggestions for further studies.

5.6.2 Summary of findings

5.6.2.1 Strategies educators use to teach natural science curriculum

Science educators applied various strategies in class. The most employed strategies were: discussion, lecture, problem solving, demonstration and presentation. It was also noted that constructivism was promoted when using these strategies.. Educators were able to identify the benefits of incorporating these strategies in science teaching.

5.6.2.2 Strengths and weaknesses of strategies

Educators acknowledged that there were strengths and weaknesses in these strategies. Educators also mentioned strategies that promoted higher order thinking such as investigation, case study, discussion and problem solving. Benefits identified were: encouraging learner participation, fostering deep thinking skills, transferrability to real world events, promoting linking of the new information to the environment and thinking skills. Lecture strategy was identified as the strategy that promoted chalk and talk with no interactive learning. Weaknesses in active engagement were mentioned by educators as time consuming with learners relying on others and becoming passive at times. Weaknesses inhibiting higher order thinking skills were identified as lack of resources, promotion of memorization and plagiarism as well as lack of participation due to financial constraints.

5.6.2.3 Educator support for science learning and promoting SL

The study findings revealed that workshops were available; educators were attending them and benefited from them. Educators acknowledged that they were getting support from other educators, heads of department and cluster educators (through cluster workshops). They also confirmed that DoE officials were giving them tremendous support, though few educators claimed that they never received support from the district office. The Province (ECDoE) is acknowledged by some of the educators as giving support. However, some educators complained that they never received support. Educators further revealed that they also received support from other structures such as SAASTA and Science Expos. It was also established in the study that, despite the support received by educators, they were also experiencing challenges that needed urgent intervention. Emergency intervention mentioned by educators were resources for science to conduct practical tasks and empowerment for content coverage through workshops.

5.6.2.4 Strategies relevant in promoting science learning and SL

It emerged from the study that the most relevant strategies acknowledged by the educators were: problem solving, demonstration, investigation, project and modelling. Relevant strategies were identified as case study, presentation, brainstorming and discussion. Strategies that were considered as not relevant for science learning and promoting SL were lecture, and question and answer. Concerning technology, educators were aware of technology integration. Some educators used technology in their lessons. Others were aware but did not have access to technology tools. A few did not have tools at all. Educators also confirmed that they were aware of science inquiry, though some did not understand certain aspects of science inquiry. Educators reported that they knew POE strategy and that they applied it in NS practical tasks, while others complained that they did not use the strategy because of attittudes and lack of resources.

5.6.2.5 Educators assessing science learning and SL

The study confirmed that educators had knowledge of assessment and when assessing students they measured students' achievement. It emerged that some educators aligned assessment using cognitive domain, while others did not. The study also found that educators did assess practical work.

5.6.3 Overall summary

The main research question was to find out which educator strategies were the most effective in promoting science learning and SL among Grade 9 learners in a rural education district. The research sub-questions sought to find out the strategies which educators used to teach natural science curriculum, the strengths and weaknesses of these strategies in promoting science learning and SL, support for educators to promote science learning and SL, relevant strategies which educators deemed as relevant in promoting science learning and SL and how educators assessed learners' science learning and SL. The objectives of the study were to ascertain the strategies used by educators to teach natural science curriculum, establish the strengths and weaknesses of these strategies to promote science learning and SL, find out how educators were supported to promote science learning and SL, find out which strategies were deemed as relevant in promoting science learning and SL and establish how educators assessed learners' science learning and promotion of SL.

As shown in sub-section 5.5.2, the triangulated data allowed to achieve all the objectives which in turn answered all research sub-questions that led to answer the main research question. It was indeed satisfying to see that the educators in the sample were highly aware of the strategies used for science learning and promoting SL and that they were able to identify those which were the most effective among Grade 9 learners. Furthermore, through pre-service training, teaching experience and in-service training, the educators were able to identify the strengths and weaknesses of the various strategies as reported by literature and identify those which promoted active learning. The data also revealed that there was some support for teachers but there was need for improved support and resources. The ICT integration faced a lot of challenges not only in terms of resources but also in terms of staff empowerment. Inadequate practical equipment and resources hindered science process experience for learners both in learning and assessment. These findings were indeed a milestone in that they overturned the general feeling that in rural South African schools, science learning and science literacy promotion were not optimally occuring. Quality improvement entails continuous monitoring, evaluation and positive intervention. It is hoped that the identification of strengths, weaknesses and challenges in science learning and promotion of SL in rural schools as revealed through this thesis will attract relevant proactive interventions from authorities beginning from the provincial department of education down to the school management team. Although the findings may not be generalised, other rural schools too may be facing similar challenges which need to be addressed.

The present researcher's personal reflection is that the study found out different aspects that promote science learning and science literacy. Although teachers were involving students to a certain extent, the study revealed different strategies that stimulate interactive learning and higher order thinking. Practical work was mostly ignored by educators due to different reasons. Hence, the study developed a framework that educators can utilize to enrich the science teaching and learning. In addition, the study has shown the usefulness of applying the identified teaching and learning science strategies to promote science learning and science literacy

Limitations of the study

Due to the long distance between the schools and the muddy roads (since Principals preferred data collection in the first quarter which was the rainy season), the present researcher had to restrict data collection to 30 schools. Some schools had to be visited more than once. Due to financial, distance and time constraints, data collection was expensive and consideration of a larger sample size was impossible. The access to one of the circuits was disrupted by the road construction company that was busy with road maintenance. In addition, the second circuit could not be reached due to gravel road which was having very big stones that made it difficult to travel the long distances between the schools. In some schools most teachers were very busy with athletics , so they were not reachable to respond to the questionnaires for my study. Another problem is that some educators were very much reluctant to particicipate in the research project due to their own unfounded reasons.

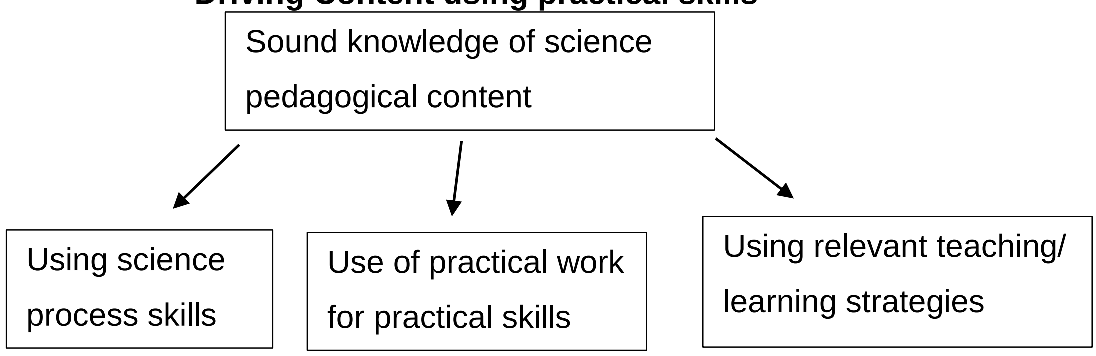
5.6.4 Recommendations

Based on the findings the following recommendations are considered relevant:

- All the stakeholders-DoE subject specialists, educator subject committees and cluster leader educators should work together and form a committee that will look at these challenges pertaining to content gap and content coverage in order to come up with strategies to solve the challenges.
- Stakeholder committees need to ensure that educator development is done and coordinated successfully for effective results
- The DoE and NGOs need to visit schools regularly to support all science educators, especially in rural areas, since educators complain that they do not receive regular support and visits.
- Organise more workshops that concentrate more on improving skills of educators in conducting experiments.
- DoE needs to ensure that resources are made available in schools, especially the science kit and laboratories.
- Encourage Principals of the schools to buy science kit from their budget rather than awaiting ECDoE support for long.
- Cluster meetings need to be encouraged by DoE officials and support educators for the effective teaching of science.
- ECDoE should organise science international conferences to promote the acquisition of science content knowledge and teaching strategies.

5.6.5 Recommended framework

Driving Content using practical skills



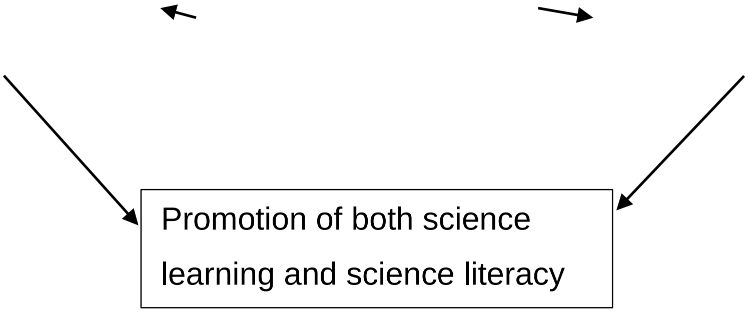


Figure 5-1: Mtsi (2018) framework: Driving science content using practical work

The above framework if implemented ought to result in effective science learning and promote SL as it shows the dynamic relationship between science learning and SL. It consists of five science aspects that work together to promote the teaching and learning of science. The framework promotes the use of science experiments to teach the content in the classroom. Therefore, it is very important that an individual should have good sound knowledge of the content, using science process skills, practical work, relevant teaching strategies for the promotion of both science learning and science literacy.

5.6.6 Recommendations for further study

There is indeed a need for further research on a wider scale, using more than one district, combining both urban and rural schools to see if and how SL is promoted. Future studies may also explore the support that senior secondary school educators get for the effective teaching and learning of science subjects. Further studies should also be carried out to investigate the strategies of assessment that enhance the effective teaching and learning of science.

REFERENCES

Abdullahi, S., & Emmanuel N. R. (2014).The role of modelling towards impacting quality education. *International Letters of Social and Humanistic Sciences, 32,* 54-61.

Abongdia, J. A. (2013). *Language ideologies in Africa: Comparative perspectives from Cameroon and South Africa*. Unpublished doctorate thesis. University of the Western Cape, Western Cape, South Africa.

Abbott, I., Middlewood, D., & Robinson, S. (2014). Prospecting for support in a wild environment: Investigating a school-to-school support system for primary school leaders. *School Leadership and Management, 34*(5), 439-453.

Abdel-Fattah, M. A. (2015). Grounded theory and action research as pillars for interpretive information systems research: A comparative study. *Egyptian Informatics Journal,* 16, 309–327.

Absolum, M., Flockton, L., Hattie, J., Hipkins, R., & Reid, I. (2009). *Directions for assessment in New Zealand: Developing learners' assessment capabilities.* Retrieved October 15, 2017, from http://assessment.tki.org.nz/Research-and readings

Achimugu, L. (2018). Effectiveness of Enriched Demonstration and Lecture instructional Strategies on Senior Secondary School Students Achievement in Junior Secondary Physical and Health Education and Senior Secondary Physical Education. *Teacher Education and Curriculum Studies, 2*(4), 47-51.

Adamson, K. Santau, A., & Lee, O. (2013). The impact of professional development on elementary educators' strategies for teaching science with diverse learners groups in urban elementary schools. *Journal of Science Teacher Education*, *24*(3), 553-571.

Adam, N. P. (2010). *Investigation of factors that influence practices of parental involvement in the development of children's literacy at senior phase school level*: A case study of a combined school in the Eastern Cape. Master's thesis. East London: University of Fort Hare.

Adejimi, A., Oyediran, O. S., & Ogunsanmi, E. B. (2010). Employing qualitatively enriched semi structured questionnaire in evaluating ICT Impact on Nigerian construction chain integration. *The Built & Human Environment Review, 3*(1), 49-62.

Ajaja, O.P. (2009). Evaluation of science teaching in secondary schools in Delta State 2–teaching of the sciences*. International Journal of Educational Sciences 1* (2), 119-129.

Aji, W.N., & Budiyono. S. (2018). The Teaching strategy of Bahasa Indonesia in curriculum 2013. *International Journal of Active Learning, 3* (2), 58-64.

Akdeniz, C. (Ed.). (2016). *Instructional process and concepts in theory and practices.* Turkey: Springer Nature.

Alacapınar, G. F. (2008). *Ornek olay yontemi ve egitim icin ornek olaylar*. Ankara, Turkiye: Anı Yayıncılık

Allen, J. M., & Wright, S. E. (2013). Integrating theory and practice in the pre-service teacher education practicum. Educators and teaching: *Theory and Practice, 20*, 136-151.

Allen, M. (2014). *Misconceptions in primary science*, (2nd ed.). England, UK: Open University Press.

Alidou, H., Boly, A., Brock-Utne, B., Diallo, Y., Heugh, K., & Wolff, H. (2006). *Optimizing learning and education in Africa–the language factor. A stock taking research on mother tongue and bilingual education in sub-Saharan Africa.* Gabon: UNESCO Institute for Education.

AlMutairi, A. N. M. (2015).The effect of using brainstorming strategy in developing creative problem solving skills among male students in Kuwait: A field study on Saud Al-Kharji School in Kuwait City*. Journal of Education and Practice, 6*(3), 222-1735.

ALshammari. M. K, (2015). Effective brainstorming in teaching social studies for elementary school. *American International Journal of Contemporary Research*, 5(2), 60-65.

Alzheimer-Europe (2009). *The four main approaches to research*. Retrieved January 23, 2018 from http://www.alzheimer-europe.org/Research/Understanding-dementia research/Types-of- research/The-four-main-approaches

Amsterdam, C., & Nkambule, G. (2018).The realities of educator support in a South African school district. *South African Journal of Education, 38*(1), 1-11.

Anney, V.N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies, 5*(2), 272-281.

Arntzen, J., Krug, D., & Wen, Z. (2008). ICT literacies and the curricular conundrum of calling all complex digital technologies tools. *International Journal of Education and Development using ICT*, *4*(4), 6-14.

Anaekwe, M.C., Nzelum, N.N., Olisakwe, S.F., & Okpala, J.U. (2010). *Principles and methods of science*. Onitsha: Sofie Publicity

Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2000). *A taxonomy for learning, teaching, and assessing:* A revision of Bloom's Taxonomy of Educational Objectives. New York: Pearson, Allyn & Bacon.

Anderson, R. A. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12

Anderson, V. (2nd ed.). *(2009). Research methods in human resource management (pp.* 6–75 & 131–230 & 149-216). London: Chartered Institute of Personnel and Development..

Anderson, J. (2010). *ICT transforming education*. *Asia and Pacific regional bureau for education.* Bangkok: UNESCO.

Aslanides, C. D., Kalfa, V., Athanasiadou, S., Gianelos, Z., & Karapatsia, V. (2016). *Advantages, disadvantages and the viability of project-based learning integration in engineering studies curriculum: The Greek case*. 44th SEFI Conference (pp. 1-10). Tampere: Finland

Australian Institute for Teaching and School Leadership (AITSL) 2012. *Australian teacher performance and development framework.* Melbourne, Australia: Retrieved November 10, 2017, from https://www.aitsl.edu.au/docs/defaultsource/default documentlibrary/australian_teacher_performance_and_development_framework_august_2012.pdf?sfvrsn=e7c2 ec3c_0.

Assessment Resource Banks. (2007). *Predict, observe, explain (POE).* Retrieved March 3, 2017, from http://arb.nzcer.org.nz/nzcer3/strategies/poe.html.

Axelson, R. D., & Flick. A. (2010). Defining student engagement change. *The Magazine of Higher Learning 43*(1), 38-43

Babbie, E. (2009). *The practice of Social research* (12th ed.). Belmont, CA: Wadsworth.

Babbie, E., & Mouton, J. (2012). *The practice of social research.* Cape Town: Oxford University Press Southern Africa.

Babajide, V. F. T. (2010). Fostering the development of practical skills among secondary school physics students: Implications for science teaching. *International Journal of Contemporary Issues in Education, 2* (Special Edition).

Bantwini, D. (2009). District professional development models as a way to introduce primary-school teachers to natural science curriculum reforms in one district in South Africa, Journal of Education for Teaching: *International research and pedagogy*, 35:2, 169-182

Bantwini, B.D., & Diko, N. (2011). Factors affecting South African district officials' capacity to provide effective teacher support. *Creative Education, 2(3),* 226–235.

Bantwini, B. D. (2017). Analysis of teaching and learning of natural sciences and technology in selected Eastern Cape Province primary schools, South Africa. *Journal of Education, 1*(67), 39-64.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bazan, D. E. (2007). *Teaching and learning strategies used by student-directed educators of middle school band.* Unpublished doctoral dissertation. Cleveland, OH: Case Western Reserve University

Berger, A.S. (2010). *Sociological research methods and technology*. Retrieved June 7, 2014, from www.sociology.org.uk/methods.pdf.

Bergman, M. (2007). *Mixed methods research*. London: SAGE.

Best, J., & Kahn, J. (2006*). Educational research*. Retrieved June 23, 2015 from http://www.getcited.org/pub/102991379

Bidokht, M. H., & Assareh, A. (2011). Life-long learners through problem-based and self-directed learning. *Procedia computer science, 3*, 1446-1453.

Billingsley, G. M., & Scheuermann, B. K. (2014). Using virtual technology to enhance field experiences for pre-service special education educators. *Teacher education and special education, 37*, 255-272.

Bilen, M. (2006). *Plandan Uygulamaya Ogretim* (7. Baskı). Ankara: Turkiye: Ani Yayıncılık.

Blance, T.M. & Durrheim, K. (2006). *Research in practice: Applied methods for the social sciences* (2nd ed.). Cape Town: UCT Press

Bless, C., & Higson-Smith, C. (2000). *Fundamentals of social research methods.* Cape Town: Juta.

Bloom, B.S. (Ed.). Engelhart, M.D., Furst, E.J., Hill, W.H., Krathwohl, D.R. (1956). *Taxonomy of educational objectives, Handbook I: The cognitive domain.* New York: David McKay Co Inc.

Black, P., & Wiliam, D. (1998a). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan, 80*(2), 139–148

Black, P., & Wiliam, D. (1998b). Assessment and classroom learning. Assessment in education: *Principles, policy & practice, 5*(1), 7-74.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M. & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist, 26* (3-4), 369-398.

Boyce, C., & Neale, P. (2006). Conducting In-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input. Retrieved March 20, 2018, from http://www. pathfind.org/site/DocServer/m_e_tool_series_indepth_interviews.pdf?docID=6301

Borrego, M., Douglas, E.P. & Amelink, C.T. (2009). Quantitative, qualitative and mixed methods research methods in engineering education. *Journal of engineering education, 98*(1), 53-66.

Bradley, E. G., & Kendall, B. (2014). A review of computer simulations in teacher education. *Journal of educational technology systems, 43*, 3-12.

Breiting, S., & Schnack, K. (2009). Education for Sustainable development. experiences from the first ESD Schools in the decade of ESD. In Uddannelse for bæredygtig udvikling i danske skoler: Erfaringer fra de første TUBU-skoler i Tiåret for UBU; (in Danish). Aarhus University: Aarhus, Denmark.

Brookhart, S. (2011). Educational assessment knowledge and skills for educators. Educational measurement. *Issues and practice, 30*(1), 3-12.

Bruner, J. S. (1961). *The act of discovery*. Harvard educational review

Bryman, A. (2007). Effective leadership in higher education: A literature review. *Studies in higher education, 32*(6), 693-710.

Bryman, A., & Bell, E. (2011). *Business research methods,* (3rd ed). New York: Oxford Press.

Brynard. P, A., Netshikhopani., A. F. (2011). Educator training challenges in implementing the national curriculum policy statement. *African Journal of Public Affairs, 4*(3), 60-72.

Burns, N., & Grove, S.K. (2003). *Understanding nursing research,* (3rd ed.). Philadelphia: Saunders.

Burns, N., & Grove, S. K. (2007). *Understanding nursing research: building an evidence-based practice,* (4th ed.). UK: Saunders Elsevier

Butler, D., Leahy, M., Shiel, G., & Cosgrove, J. (2013). *A consultative paper building towards a learning society: a national digital strategy for schools*. Retrieved September 18, 2017, from http://www.education.ie/en/Schools-Colleges/Information/Information Communications-Technology-ICT-in-Schools/Digital-Strategy-for-Schools/Building-Towards-a-Learning-Society-A-National-Digital-Strategy-for-Schools- Consultative-Paper.pdf

Çakmak, Z., & Akgün, I. H. (2017). A theoretical perspective on the case study method. *Journal of Education and Learning, 7*(1), 96-102.

Chamberlain, V.M., & Kelly K.M. (1981). Creative home economic instruction. USA: Mac Grow Hill lank.

Chilisa, B. (2012). *Indigenous research Methodologies*. London: SAGE.

Chilisa, B., & Kawulich, B. (2012). Selecting a research approach: paradigm, methodology, and methods. In C. Wagner, B. Kawulich & M. Garner, *Doing social research: A global context* (pp. 51-61). London: McGraw-Hill.

CBI report (2015) *Tomorrows World. Inspiring primary scientists.* Brunel University. Available at http://www.cbi.org.uk/insightandanalysis/Tomorrow-s-world/ Accessed 20/10/17

Chingombe, S. I. (2013). Impacts of the demonstration method in the teaching and learning of hearing impaired children. *IOSR Journal of Humanities And Social Science (IOSR-JHSS), 12*(1), 48-54.

Collins English Dictionary. (2009). *Complete & unabridged* (10th ed.). New York: Harper Collins.

Choi, K., Lee, H., Shin, N., Kim, S., & Krajcik, J. (2011). Re-conceptualization of scientific literacy in South Korea for the 21st century. *Journal of research in science teaching, 48*(6), 670-697.
Cochran, K. F. (1993). Pedagogical content knowing: an integrative model for teacher preparation. *Journal of Teacher Education, 44*(4), 263-272.
Coetzee, J. (2017). Reform-based approaches in the learning and teaching for conceptual understanding of calculus for diploma studies at a South African university. University of Fort Hare.
Coe, R. and Aloisi, C. and Higgins, S. & Major, L.E. (2014). *What makes great teaching? Review of the underpinning research*, Project Report. Sutton Trust: London.
Collis, J., & Hussey, R. (2003). *Business research: a practical guide for undergraduate and postgraduate students* (2nd ed.). Basingstoke: Palgrave Macmillan.
Cortey, S. (2013). *Mixed methods*. Retrieved June 16, 2014, from www.facweb.cs.depaul.edu/.../csc426-s2013-Week6-Mixed-Research.pptx.
Cohen, L., Manion, K., & Morrison, K. (2007). *Research methods in education* (6th ed.). London: Routledge
Crawford, M. (2014). *Developing as an educational leader and manager*. London: SAGE.
Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). London: Sage
Cresswell, J. W., & V. L. Plano-Clark. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage Publications.
Creswell, J.W. (2008). *Research Design: Qualitative, Quantitative and Mixed approaches*. (3rd ed.) California: Sage Publications.
Creswell, J.W. (2009). Research design: Qualitative, quantitative and mixed methods approaches (3rd ed.). los angeles: sage.
Creswell, J. W. & Plano-Clark, v. l. (2011). Designing and conducting mixed methods research. (2nd ed.). Thousand Oaks, CA: Sage. Cronholm
Creswell, J.W. (2013). *Qualitative inquiry and research design: choosing among five approaches* (3rd ed.). Thousand Oaks, CA: Sage.
Creswell, J.W. (2014*). Research design: quantitative and qualitative mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage.
Crooks, T. (1998). The impact of classroom evaluation practices on students. *Review of Educational Research, 58*(4), 438–481.
Dahsah, C., & Faikhamta, C. (2008). Science education in Thailand: Science curriculum reform in transition. In R.K. Coll & N. Taylor (Eds.), *Science education in context: An international examination of the influence of context on science curricula development and implementation* (pp. 291-300). Rotterdam: Sense.
Daluba, N.E. (2013) Effect of demonstration method of teaching on students' achievement in agricultural science. *World Journal of Education, 3*(6),1-7.
Department of Science and Technology Republic of South Africa (2016). Science engaging with society to build a better future for all. Retrieved January 2, 2018, from http://G:/TEACHER%20SUPPORT%20IN%20SCIENCE%20TEACHING/NRF-SAASTA-Highlights-Report-D6-with-cover.pdf
De Lisley, J. (2011). The benefits and challenges of mixing methods and methodologies: Lessons learnt from implementing qualitatively led mixed

methods research designs in Trinidad and Tobago. *Caribbean Curriculum, 18*, 87–120.
deMunck, V. C., & Sobo, E. J. (Eds) (1998). *Using methods in the field: a practical introduction and casebook.* Walnut Creek, CA: AltaMira Press
Demirel, O. (2009). *Ogretim İlke ve Yontemleri Ogretme Sanatı* (15. Baskı). Ankara, Turkiye: Pegem Akademi Yayıncılık
Denzin, N. K., & Lincoln, Y. S. (2003). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed.) (pp. 1-28). Thousand Oaks, CA: Sage.
Denzin, N. K., & L. S. Lincoln. (2005). *Handbook of qualitative research*. London: Sage.
Denzin, N.K., & Lincoln, Y.S. (2008). *The Landscape of Qualitative Research*. London: Sage publications.
Denscombe, M. (2008) The length of responses to open-ended questions: a comparison of online and paper questionnaires in terms of a mode effect. *Social Science Computer Review, 26*(3), 359-368
Denscombe, M. (2010). *The good research guide, for small-scale social research projects.* (4th ed.). Open University Press.
DeWalt, K. M., & DeWalt, B. R. (1998). Participant observation. In H. R. Bernard (Ed.), *Handbook of methods in cultural anthropology* (pp.259-300). Walnut Creek: AltaMira Press.
Digital strategy for schools consultative paper (2013). Retrieved October 23, 2017, from http://www.education.ie/en/Schools-Colleges/Information/Information-Communications-Technology-ICT-in-Schools/Digital-Strategy-for-Schools/Building-Towards-a-Learning-Society-A-National-Digital- Strategy-for-Schools-Consultative-Paper.pdf)

Donaldson, S. I., Christie, C. A., & Mark, M.M. 2014. (eds.). *What counts as credible evidence in applied research and evaluation practice?* California: Sage
Dunlop, A.L. (2013). Qualitative and mixed methods. *For emerging medical services research*. Retrieved May 10, 2014, from www.naemsp.org/.../2013%20Annual%20Meeting%20Handouts/HAND.
Dragos, V., & Mih, V. (2015). Scientific Literacy in School. *Procedia Social and Behavioral Science, 209*,167-172.
Drost, E.A. (2011). Validity and reliability in social science research. *Education Research and Perspectives 38*(1),105-123.
Ellis V 2007. Taking subject knowledge seriously: from professional knowledge recipes to complex conceptualizations of teacher development. *Curriculum Journal, 18*(4), 447-462.
Edwards, F. (2013) Quality assessment by science educators: Five focus areas. Science *Educational International,* 24(2), 212- 226.
Edvantia (2005). Research digest: Effective instructional strategies. Charleston, WV: Appalachia Educational Laboratory. Retrieved January 1, 2016, from http://sites.edvantia.org/pdta/pdf/ Effective_Instructional_Strategies.pdf.
Ekeyi, D. N. (2013). Effect of demonstration method of teaching on students' achievement in agricultural science. *World Journal of Education*, 3 (6), 1-7
European Commission (2015) Report to The European Commission of the expert group on science education, science education for responsible citizenship. Directorate-General for research and innovation science with and for society, EUR 26893 EN.

Eristi, B., & Akdeniz, C. (2012). Development of a scale to diagnose instructional strategies. *Contemporary Educational Technology, 3*(2),141-161.

Everset, T. (2014). Resolving the qual-quan debate in health care research. *Academic Journals, 5*(1), 6-15

Earnest, J., & Treagust, D. (2007). *Educational reform in countries under transition*. Rotterdam: Sense Publishers.

Fensham, P. (2008). *Science Education Policy-making: Eleven emerging issues. 1-47*

Fletcher, A. (2015). Defining student engagement: a literature review. *Soundout: Promoting meaningful student involvement, student voice and student engagement*. Retrieved November 12, 2017, from https://soundout.org/defining-student-engagement-a-literature-review/.

Foster, J.S., & Shiel-Rolle, N. (2011). Building scientific literacy through summer science camps: a strategy for design, implementation and assessment. *Science Education International, 22*(2), 85-98.

Fraser-Abder, P. (2011). *Teaching budding scientists: Fostering scientific inquiry with diverse learners in grades 3–5.* Upper Saddle River: Pearson

Gatawa, B. S. M. (1990). *The Politics of the school Curriculum*: *An Introduction*. Harare: College Press.

Ghumdia, A. A. (2016). Effects of inquiry-based teaching strategy on students' science process skills acquisition in some selected biology concepts in secondary schools in Borno State. *International Journal of Scientific Research,1*(2), 96-106.

Gülbahar, Y., & Tinmaz, H. (2006). Implementing project-based learning and e-portfolio assessment in an undergraduate course. *Journal of Research on Technology in Education, 38*(3), 309-327.

Gess-Newsome, J., & Lederman, N.G., (2015) (eds.). *Examining pedagogical content knowledge: The construct and its implications for science education.* Hingham: Kluwer Academic Publishers.

Girard, M. P., & Trapp, P. (2011). "An exploratory study of class presentations and peer evaluations: Do students perceive benefits?

Girod, M., & Girod, G. (2008). Simulation and the need for quality practice in teacher preparation. *Journal of Technology and Teacher Education,16*, 307-337.

Given, L. M. (2008). *The Sage encyclopedia of qualitative research methods*. Thousand Oaks: Sage

Gott, R., & Duggan, S. (1996). Practical work: Its role in the understanding of evidence in science. *International Journal of Science Education*, *18*(7), 791–806. doi:10.1080/0950069960180705

Gosa, S. (2018). Eskom extends science enhancement programme. Go & Express. Retrieved April 15, 2018, from https://www.pressreader.com/south-africa/go-express/20180301

Gray, D. E. 2014. *Doing research in the real world*. (3rd Ed.). London: Sage.

Greene, J. C. (2007). *Mixed methods in social inquiry.* San Francisco: John Wiley & Sons.

Grossman, P. L, Wilson, S. M., & Shulman, L. S. (1989). Educators of substance: subject matter knowledge for teaching. In M. C. Reynolds (Ed.), Knowledge Base for the Beginning reseacher (pp. 23-46). Oxford: Pergamon.

Gozutok, D. (2011). *Ogretim İlke ve Yontemleri* (3. Basking). Ankara, Turkiye: Ekinoks Yayınevi.

Gülbahar, Y. & Tinmaz, H. (2006). Implementing PBL and E-Portfolio assessment in an undergraduate course. *Journal Of Research On Technology In Education,38*(3), 309-327.

Grauer B, I. (2014). *Secondary science teachers' use of the affective domain in science education*. Doctor of philosophy. Manhattan, Kansas State University.

Gwarinda, T.C. (1993). *The Practice of Education* .Bulawayo, R.C.P Belmont Press.

Habteselassie. T.A. (2015*). Exploring inquiry based education at secondary school level.* Master's thesis. Pretoria: University of Pretoria.

Hand, B. M., Prain, V., & Yore, L. D. (2001). Sequential writing tasks' influence on science learning. In P. Tynjala, L. Mason, & K. Lonka (Eds.), *Writing as a learning tool: Integrating theory and practice* (pp.105-129) Dordrecht, The Netherlands: Kluwer*.*

Harlen, W. (2014). Helping children's development of inquiry skills. *Inquiry in Primary Science Education* (IPSE). Retrieved January, 1 2017, from http://prisci.net/ipse/papers/3%20IPSE%20Volume%201%20No%201%20Wynne%20Harlen%20p%205%20%2019.pdf

Harrits, G. S. (2011). More than method? A discussion of paradigm differences within mixed methods research. *Journal of Mixed Methods Research, 5*, 150–166.

Hay, P., & Penney, D. (2012). *Assessment in physical education: a sociocultural perspective.* Florence, KY: Taylor and Francis.

Hiang, P. S. (2005). *Pedagogy of Science.* Kuala Lumpur: Percetakan Sentosa (K.L) Sdn.Bhd.

Hidayati. L., & Pardjono. P, (2018). *The implementation of role-play in education of pre-service vocational teacher*. The Consortium of Asia-Pacific education universities. IOP Conf. Series: Materials Science and Engineering 296 (2018) 012016: IOP Publishing limited

Henze, I., Van Driel, J. H., & Verloop, N. (2008). Development of experienced science educators' pedagogical content knowledge of models of the solar system and the universe. *International Journal of Science Education, 30*(10),1321-1342. doi:10.1080/ 09500690802187017

Hesapcıoglu, M. (2011). *Ogretim İlke ve yontemleri, egitim programları ve ogretim*. Ankara, Turkiye: Nobel Yayın Dagıtım.

Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values*. The Netherlands: Sense.

Hohenshell. L. M. (2004). Enhancing learning science and promoting for learning science and promoting SL through implementation of writing –to-leaner strategies: exploratory studies in high school biology. Retrieved January, 20, 2018, from http://lib.dr.lastate.edu/rtd/1166

Hughes, S., & Scholtz, F. (2015). Increasing the impact of a business simulation: The role of reflection. *The International Journal of Management Education, 13,* 350-361

IAAR, (2012). Determining the level of the use of writing strategies by prospective classroom .educators. International Journal of Academic Research, 4(6), 49-56.doi:10.7813/2075-4124.2012/4-6/b.8

Ibe, E (2004). Effect of guided inquired and demonstration on science process skills (SPS) acquisition among secondary school biology students. *Journal of science teacher association of Nigeria, 38* (1& 2), 58-63.

Ibrahim, A.M. (2012). Thematic analysis: A critical review of its process and evaluation. *WEI International European Academic Conference Proceedings*. Retrieved March 8, 2018, from https://www.westeastinstitute.com/wp-content/uploads/2012/10/ZG12-191-Mohammed-Ibrahim-Alhojailan-Full-Paper.pdf

ICSU. 2011. Report of the ICSU Ad-hoc Review Panel on Science Education. *International Council for Science*. Rtrieved November, 13, 2017, from https://council.science/publications/report-of-the-icsu-ad-hoc-review-panel-on-science-education-2011

Ikwumelu, B., & Oyibe, Y. (2014). The comparative effects of simulation games and brainstorming instructional strategies on junior secondary school students' achievement in social studies in Nigeria. *African Research Review, 5*(3), 64-80. doi:10.4314/afrrev.v5i3.67342

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). *Using mixed-methods sequential explanatory design: from theory to practice.* Online: Retrieved July, 14, 2018 from: http://fmx.sagepub.com/content/18/1/3.refs.html

Ivankova, N. V., Creswell, J. W., & Plano C. V. L. (2007). Foundations and approaches to mixed methods research. In K. Maree (Ed.). *First steps in research,* (pp. 253- 280). Pretoria: Van Schaik.

Ikwumelu, B., & Oyibe, Y. (2014). The comparative effects of simulation games and brainstorming instructional strategies on junior secondary school students 'achievement in social studies in Nigeria. *African Research Review, 5*(3). doi:10.4314/afrrev.v5i3.67342

Jita, C.L., & Mokhele, M.L. (2014). When teacher clusters work: selected experiences of South African Educators with the cluster approach to professional development. *South African Journal of Education, 34*(2), 1-15.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26

Johnson, R.B., Onwuegbuzie, J., & Tuner, A. (2007). Toward a definition of mixed method research. *Journal of Mixed Methods Research 2*, 112-133.

Johnson, R.B. (2014). *Mixed methods research design and analysis with validity*: A Pruner. USA: University of South Alabama.

Kalaian, S.A. (2011). *Research design. Encyclopedia of Survey research methods*. London: SAGE.

Kamberelis, G., & Dimitriadis, G. (2013). *Focus groups from structured interviews to collective conversations.* New York: Routledge.

Keller, C. (2016). *Using STEM case studies to prepare today's students for tomorrow's jobs an evaluation of spark 101 interactive STEM videos*. Retrieved June 23, 2017, from http://www.spark101.org/media/user_files/2016-03-07_SparkEvaluation-Final.pdf

Kezar, A., & Dee, J. R. 2011. Conducting multi-paradigm inquiry in the study of higher education organizations and governance: Transforming research perspectives on colleges and universities. In J. C. Smart & M. B. Paulsen, (Eds.), *Higher education: handbook of theory and research* (pp. 265-316). London: Springer.

Killen, R. (2007). *Effective teaching strategies: Lessons from research and practice* (4th ed.). South Melbourne, Victoria, Australia: Cengage Learning.

Kibirige, I., Osodo, J., & Tlala, K., (2014). The effect of predict-observe-explain strategy on learner's misconceptions about dissolved salts. Mediterranean Journal of Social Sciences, 5(4), 300-310.

Kiriakidis, P., & Jenkins-Williams, E. (2013). A case study of mentor-to-mentee program to help African males graduate from high school. *Postmodern Openings Journal, 4*(4), 81-93.

Krathwohl, D.R., Bloom, B.S., & Masia, B.B. (1973). *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain.* New York: David McKay Co., Inc.

Krathwohl, D.R., Bloom, B.S., & Masia, B.B. (1964*). Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain.* New York: David McKay Co., Inc.

Kriek, J., & Grayson, D. (2009). A holistic professional development model for South African physical science educators. *South African Journal of Education, 29*, 185-203.

Koehler, M. & Mishra, P. 2009. What is technological pedagogical content knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Kuada, J.E. (2012). *Research Methodology: A project guide for university learners*. Frederiksberg: Samfundslitteratur Press.

Kucukahmet, L. (2009). *Ogretim İlke ve yontemleri* (23. Baskı). Ankara, Turkiye: Nobel Yayın Dagıtım.

Kumur, R. (2011). *Research methodology. A step by step guide for beginners*. London: Sage.

Kurt.H, Ekici. G, Aksu. O, Aktas. M. (2013). The most important concepts of transport and circulatory systems Turkish biology student educators' cognitive structure. *Global Journal of Medical, Physical and Health Education,1*(1), 1-20.

Laugksch, R.C. (2000). *Scientific Literacy: A conceptual overview*: John Wiley & Sons, Inc.

Lateef, F. (2010). Simulation-based learning: Just like the real thing. *Journal of Emergencies, Trauma, and Shock, 3*(4), 348–352. doi.org/10.4103/0974-2700.70743

Lee, C. I., & Tsai, F. Y. (2004). Internet PBL environment: The effects of thinking styles on learning transfer. *Journal of Computer Assisted Learning, 20*(1), 31-39.

Leemkuil, H., Jong, T. D., & Ootes, S. (2000). Review of educational games and simulations. *KITS Consortium*, 110–119.

Leung, L. (2015). Validity, reliability, and generalizability in qualitative research. *Journal of Family Medicine and Primary Care, 4*(3), 324-327.

Vygotsky, L. (1978). *Mind in society*. *The development of higher psychological processes.* Cambridge, Massachusetts: Harvard University Press.

Li LI., & Zhang F 2015. Beginning educators' induction in Australia: Characteristics, experiences and development trend. *Studies in Sociology of Science, 6*(1), 35–39. doi.org/10.3968/6387

Lincoln, Y.S. & Guba, E.G. (1985).Naturalistic inquiry. Newbury Park, CA: Sage.

Lincoln, Y.S., Lynham, S.A. & Guba, E.G. (2011). Paradigmatic controversies, contradictions, and emerging confluences, revisited. In N.K. Denzin & Y.S. Lincoln (Eds) (pp. 97-128).*The Sage handbook of qualitative research*. Beverly Hills, CA: Sage.

Lichtman, M. 2013. *Qualitative research in education: A users guide*. *3rd Ed*. UK:
Liu, X. (2009). Beyond SL: Science and the public. *International Journal of Environmental and Science Education*, *4*(3), 301–311.
Luu, K., & Freeman, J. (2011). An analysis of the relationship between information and communication technology (ICT) and for learning science and promoting SL in Canada and Australia. *Computers & Education*, *56*(4),1072-1082.
Lourenco, O., & Machado, A. (1996). In defence of Piaget's theory: A reply to 10 common criticisms. *American Psychological Association*. 103(1), 143-164
Magnusson, S., Krajcik, J., & Borko, H. (in press (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. Lederman (Eds.), *Yearbook Of the Association For The Education Of Educators of Science (pp. 95-132)*. Boston: Kluwer.
Macugay, E. B., & Bernardo, A. B. (2013). Science coursework and pedagogical beliefs of science educators: The case of science educators in the Philippines. *Science Education International, 24*(1), 63-77.
Marmah, A. A. (2014). Students' perception about the lecture as a method of teaching in tertiary institutions. Views of students from college of technology eduction, Kumasi (coltek). *International Journal of Education and Research*, 2(6), 601-612.
Mandor, A.K. (2002). *Effects of constructivist model on acquisition of science process skill among junior secondary students.* An unpublished M.Ed. Thesis, Department of Science Education, University of Nigeria, Nsukka.
Maree, J. 2018. First steps in research. 2nd ed. Van Schaik. South Africa.
Mason, J. (2004). *Semi-structured Interview*. Retrieved August 20, 2017, from http://srmo.sagepub.com/view/the-sage-encyclopedia-of-social-science-research-methods/n909.xml.
Mathers, N., Fox, N., & Hunn, A. (2009). *Surveys and questionnaires*. The NIHR RDS for the East Midlands/Yorkshire & the Humber. Retrieved March 2, 2018 from www.rds-idlends.nihr.ac.uc.
Marzano, R. J. (2003). *What works in schools: Translating research into action?* Alexandria, VA: ASCD.
Mavhunga, E. (2014). Improving PCK and CK in chemistry pre-service educators. In M. Askew, M. Venkat, M. Rollnick & J. Loughran (Eds.), Exploring Content Knowledge for Teaching Science and Mathematics: Windows into teacher thinking (pp. 29-49). Abington, UK: Routledge.
Mawhirter, D. A., & Garofalo, P. F. (2016). Expect the unexpected: Simulation games as a teaching strategy. *Clinical Simulation in Nursing,12*(4),132–136. doi. org/10.1016/j.ecns.2015.12.009
Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., & Soloway, E. (1997). Enacting project-based science. *The Elementary School Journal, 97*(4), 341-358.
Maxcy, S. J. (2003). Pragmatic threads in mixed methods research in the social sciences: The search for multiple modes of inquiry and the end of the philosophy of formalism. In A.Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 52-89).Thousand Oaks, CA: Sage.
Magwa, S., & Magwa, W. (2015). *A guide to conducting research: A student handbook.* Singapore: Strategic Book Publishing and Rights Co. LLC.
Mbowane C.K., Devilliers J.J. R., & Braun, M.W.H. (2017). Teacher participation in science fairs as professional development in South Africa. *South African Journal of Science,113* (7/8), 1-7. doi.org/10.17.159/sajs. 2017/20160364

McFarland, E. (2005). Using demonstration in teaching physics. *La Physique Au Canada,* 87-89.
McGaghie, W.C., Bordage, G., Shea, J.A. (2010). Problem statement, conceptual framework and research questions. *Academic Medicine, 76*(9), 923-924
McKeachie, W. (1997). Student ratings: The validity of use. *American Psychologist, 52*(11),1218-1225.
McMillan, J.H., & Schumacher, S. (2010). *Research in education*. New York: Harper
McPherson, R., Tyler-Wood, T., Mcenturff, A., & Peak, P. (2011). Using a computerized classroom simulation to prepare pre- service educators. *Journal of Technology and Teacher Education,19*(1), 93-110.
Mestry R., Hendricks, I., & Bisschoff, T. (2009). Perceptions of educators on the benefits of teacher development programmes in one province of South Africa. *South African Journal of Education, 29*, 475-490.
Mertens, D. M. (2010). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods, (*3rd ed.). Thousand Oaks, CA: Sage.
Mills H.R. (1991). *Teaching and training*. Hong Kong, Macmillan Education Ltd.
Migiro, S.O., & Magangi, B.A. (2010). Mixed methods: A review of literature and future of the new research paradigm. *African Journal of Business Management, 5*(10), 3757-3764.
Millar, R. (2007). Twenty first century science: Insights from the design and implementation of a scientific literacy approach in school science. *International Journal of Science Education, 28* (13), 1499-1521.
Millar, R., & Osborne, J. (1998). (Eds.). *Beyond 2000: Science education for the future,* 2000-2032
Ministry of Education. (2007). *The New Zealand curriculum for English medium teaching and learning in years 1-13.* Wellington, N.Z.: Learning Media
Ministry of Education. (2011). Assessment: Schooling sector. Ministry of Education
Mirskaya, E. (2007). National scientific communities in the globalized world: Global ICTs as a tool of modernization among the Russian Academic Community. *Perspectives on Global Development and Technology,6*(4), 557-566. doi: 10.1163/156914907X253198
Moore, A. (2016). Stepping up support for new educators. *Educational Leadership, 73*(8), 60-64.
Mpanza, N.M. (2013). *A case study of educators' implementation of the grade four natural science curriculum*. Master's thesis. Durban: University of KwaZulu Natal.
Morgil, I, Seyhan, H. G., Alsan, E. U., & Temel, S. (2008). The effect of web-based project applications on students‟ attitudes towards chemistry. *Turkish Online Journal of Distance Education-Tojde, 9*(2), 220-237.
Moss, P. A., Girard, B. J., & Greeno, J. G. (2008). Sociocultural implications for assessment II: Professional learning, evaluation, and accountability. In P. A. Moss, D. C. Pullin, J. P. Gee, E. H. Haertel, & L. J. Young (Eds.), *Assessment, equity, and opportunity to learn*. New York: Cambridge University Press.
Mtsi, N. (2015). *Implementation of the natural science curriculum in selected rural junior secondary Schools in the Cofimvaba Education District*, Master's thesis. East London: University of Fort Hare.

Mtsi, N., & Maphosa. C. (2016). Challenges encountered in the teaching and learning of natural science in rural schools in South Africa. *Journal of Social Science, 47*(1), 58-67.

Mtsi, N., Maphosa, C., & Moyo, G. (2016). Exploring educators' preparedness to teach natural sciences at the senior phase of South African secondary schools. *Journal of Educational Studies 15*(2),108-135

Mohammed, S.A. (2013) Promoting Scientific Literacy by Using ICT in Science Teaching. *International Education Studies, 6*(9), 175-186.

Mouton, J. (2001). *Basic concepts in the methodology of the social sciences. Human sciences research*. Pretoria: Van Schaik publishers.

Mugabo, R. L. (2012). *Introduction of inquiry-based science teaching in Rwandan lower secondary schools: educators' attitudes and perceptions*. Doctoral dissertation. Durban: University of KwaZulu-Natal.

Mundi, N. E. (2006). The state of students' academic achievement in secondary school agricultural science in Kogi State. *Teacher Education Journal (TEJ), 12*(1),14-19.

Murcia, K. (2007). Science for the 21st century: Teaching for scientific literacy in the primary classroom. *Teaching Science, 53*(2), 17-21.

Myers, G. (1998) Displaying opinions: topics and disagreement in focus groups. *Language in Society,* 27(1), 85-111.

Myers, M. D. (2009). *Qualitative research in business & management*. London: SAGE.

Nas, R. (2006). *Hayat Bilgisi ve Sosyal Bilgiler Ogretimi* (3. Baskı), Bursa, Turkiye: Ezgi Kitabevi.

National Research Council (NRC). (2007). Taking science to school: Learning and teaching science in grades K-8. In R. A. Duschl, H. A. Schweingruber., & A. W. Shouse (Eds.), Committee on science learning, kindergarten through eighth grade. Washington, DC: The National Academies Press.

National Research Council (NRC). (2012). *A framework for K-12 science education: practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy Press

National Education Evaluation & Development Unit (2013). National report 2012: The state of literacy teaching and teaching in the foundation phase. Retrieved February, 19, 2018, from http://uscdn.creamermedia.co.za/assets/articles/attachments /44530_needu_full_report_2012.pdf.

Naumescu, A.K. 2008. Science teacher competencies. In a Knowledge Based Society, *Acta Didactica Napocensia*, 1(1), 25-31.

NSTA. (2009). *NSTA Position Statement*. International Science Education and the National Science Educators Association

Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education*, *87*, 224-240.

Noel, M. (2007). Elements of a winning field trip. Kappa Delta Pi Record, 44 (1), 42-44.

Nkambule, G., & Amsterdam, C. (2018). The realities of educator support in a South African school district. *South African Journal of Education*, 38(1), 1-11. doi.org/10.15700/saje.v38n1a1433

Neuman, W. L. (2006). *Social research methods: Qualitative and quantitative approaches* (6th ed.). Boston: Pearson.

Neuman, W.L. (2008). *Understanding research*. New York: Allyn & Bacon

Neuman, W. L. (2011). *Basics of social research: Qualitative and quantitative approaches*. New York: Prentice Hall

Nurshamshida, Md. S. Nabilah, A. b. ,Nurlatifah, Y. (2013). Strategies of teachingscience using an inquirybased science education(IBSE) by novice chemistryeducators. 6th international conference on university learning and teaching (InCULT 2012). *Procedia-Social and Behavioral Sciences*, 90, 583-592.

Nurhuda., Lukito, A., & Masriyah, D. (2018). Effectiveness of cooperative learning instructional tools with predict-observe-explain strategy on the topic of cuboid and cube volume. *Journal of Physics Conference Series 947*(1), 1-5. doi :10.1088/1742-6596/947/1/012052

Nesmith (2017). *Electronic Journal of Science Education.* Retrieved February 2, 2018 from http://www.ejse.southwestern.edu

Ngubeni, T. (2014). *SA eLearning under the spot light*. Retrieved January 23, 2018, from http: // www.itweb.co.za/index.php?option=com content & view =article & id=135380

O'Connell, C. (2014). *African European Mediterranean academies for science education (AEMASE).* Inquiry-Based Science Education. Berlin: All European Academic.

ODE, (2014). *Classroom strategies for interactive learning.* Newark, DE International Reading Association.

Ofsted (2013). *Maintaining curiosity: Science Education in schools*. Retrieved November 23, 2017 from https://www.gov.uk/government/publications/

Ofsted (2016), *Foreign languages and science provision in primary schools.* Retrieved May 7, 2017 from http://www.ofsted.gov.uk

Ojo, A. O. (2007). *Effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test.* Retrieved March 14, 2017 from Educational Research and Review: academicjournal.org/err/PDF/pdf%202007/Jun/sola%20and%20ojo.pdf

Okada A. (2013). Ambientes emergentes para coaprender e co-investigar em rede. VIII. *International Conference of ICT in Education -Challenges* (pp. 1-13) Minho Portugal

Oluwatelure, T.A. 2012. Investigation into the scientific literacy level of the Nigerian University undergraduates. *British Journal of Education, Society & Behavioural Science, 2*(2),139-149.

Organisation for Economic Cooperation and Development (OECD). (2009). *Creating Effective Teaching and Learning Environment: First results from* TALIS-PISA, Paris: OECD Publishing.

OECD. (2006). *The Programme for International Student Assessment (PISA). Science, 333*(3), 1-117. Retrieved October 10, 2017 from http://doi.org/10.1002/bse

OECD (2015). *Learners, computers and learning making the connection.* Retrieved September 7, 2017 from http://dx.doi.org/10.1787/9789264239555-en

OECD (2016).*Teaching Strategies for Instructional Quality Insights from TALIS-PISA*. Paris: OECD Publishing.

Phasha, T. Bipath, K., & Beckmann, J. (2016). Educators' Experiences Regarding Continuous Professional Development and the Curriculum Assessment Policy Statement. *Int J Edu Sci, 14*(1, 2), 69-78

Pathak, A., & Intratat, C. (2012). Use of semi-structured interviews to investigate teacher perceptions of student collaboration. *Malaysian journal of ELT Research, 8*(1), 2-9.

Patton, M.Q. (2002). *Qualitative research & evaluation methods*. Thousand Oaks, CA: Sage.

Park, S., & Olivier, J.S. (2007). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual Tool to Understand Educators as Professionals. *Research in Science Education, 38*(3), 261-284. doi: 10:02: 18/111 65-007-9049-6

Patrick, H., & Yoon, C. (2004). Early adolescents' motivation during science investigation. *The Journal of Educational Research, 97*(6), 319-330. doi:10.3200/JOER.97.6.319-328

Perry, J. N. (2009). *What is Simulation.* Retrieved February 18, 2018, from Saskatoon: http://olc.spsd.sk.cs/DE/PD/INSTR/strats/simui/index.html

Phellas, C.N., Bloch, A., & Seale, C. (2011). *Structured methods: Interviews, questionnaires and observations*. Retrieved May 5, 2018, from http://www.researchgate.net/.../9c96053a11b0c7d2fe.docx

Piaget, J. (1962). The stages of the intellectual development of the child. Bulletin of the Menninger Clinic*. Bulletin of the Menninger Clinic, 26*(3), 1120-1128.

PISA 2012 *Results in Focus- What is 15 year-olds know and what they can do with what they know*, OECD, 2014, pp.1-44. http://www.oecd.org/pisa/keyfindings/PISA-2012-resultsUS.pdf

Ponce, O.A., & Pagan-Maldonado, N. (2015). Mixed methods research in education: Capturing the complexity of the profession. *International Journal of Educational Excellence 1*(1), 11-135.

Reddy, V., Visser, M., Winnaar, L., Arends, F., Juan, A., Prinsloo, C., & Isdale, K. (2015). Highlights of mathematics and science achievement of Grade 9 South African learners. *Trends in International Mathematics and Science Study* (TIMSS). Human Sciences Research Council, 1-19.

Richardson, V. E. (2001). *Handbook of research on teaching* (4th ed.). New York: Macmillan

Royal Society, (2010). *The scientific century securing our future prosperity.* Retrieved December 27, 2017 from http://www.royalsociety.org

Rubin, A. and Babbie, E.R. (2015). *Empowerment Series: Essential methods for social work* (4th ed.). Boston: Cengage Learning.

Rundle, N. (2016). *Guidelines for good assessment practice* (3rd ed.). University of Tasmania: Tasmanian Institute of Learning and Teaching.

Rosenburg, E. (2007). *Education for sustainable development within business, society, governmental and educational institutions*. Retrieved February 16, 2010 from Enviropaedia.com: http://www.enviropaedia.com/topic/default,php?topic_id=262

Rodger. B, Barry, M., & Robert, L. (2009). PISA 2006: An Assessment of Scientific Literacy. *Journal of research in science teaching.* 46 (8), 865 – 883

Salama . Y., & Chennaoui. M. (2016).Teaching strategies for developing for learning science and promoting SL on learners' achievement in Biology. *ASRO Journal of education 1*(1), 6-19.

Salamon, E. (2007). *Scientific Literacy in Higher Education*. University of Calgary: Commissioned by the Tamaratt Teaching Professorship.

Sandiford, P.J. (2015) Participant observation as ethnography or ethnography as participant observation in organizational research. In Strang, K.D. (ed) The

palgrave handbook of research design in business and management, (pp. 411-446), New York: Palgrave Macmillan.
Saskatchewan Education Department. (1985). *Toward the year 2000: Future directions in professional practice.* Regina, SK: Saskatchewan Education Department.
Saskatchewan Education Department. (1991). *Instructional approaches: A framework for professional practice.* Regina, SK: Saskatchewan Education Department.
Saowapak, T., Wanrawee. C., Pintip, R., & Duangjai, N. (2010). Development of a predict-observe-explain strategy for teaching flow injection at undergraduate chemistry. *The International Journal of Learning, 17*(8),137-150.
Schwab, J. J. (1978). *Science, Curriculum and Liberal Education*, Chicago, US: University of Chicago Press
Set, B., Hadman, J., & Ashipala, D.O. (2017). An investigation into how grade 5 educators teach natural science concepts in three western cape primary schools. *World Journal of Education 7*(1), 33-43.
Sedgwick, M. L. (1998). *Teacher burnout, stressful student misbehavior and the strategies educators use to influence that misbehavior*. Unpublished doctoral dissertation. Retrieved January 20, 2018, from ProQuest Digital Dissertations (304440353).
Silverman, D. (2013). *Doing qualitative research* (4th ed.). London: Sage Publications Inc.
Simsek, A. (2011). *Ogretim Tasarımı. [Instructional design]*. Ankara: Nobel.
Simpson E.J. (1972). *The Classification of Educational Objectives in the Psychomotor Domain.* Washington, DC: Gryphon House.
Shamsudin, N., Abdullah, N., & Yaamat, N. (2012). Strategies of teaching science using an inquiry based science education (IBSE) by Novice Chemistry Educators. *Faculty of Education, University Teknologi, MARA, Shah Alam 40200, Selangor, Malaysia.*
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.
Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.
South Africa. Department of Education. (2005). *Curriculum 2005: Revised national curriculum statement grades R-9: Natural Sciences.* Pretoria: The Department.
South Africa. Department of Education. (2008). Foundations for Learning Campaign: 2008-2011. Government Gazette no. 30880. Pretoria: Government Printer.
South Africa. Department of Basic Education (2011). *National curriculum statement grades R-9*: *Natural sciences*. Pretoria: The Department.
South Africa. Department of Education and Skills (2013). Chief inspector's report 2010 -2012. Retrieved September 10, 2017 from http://www.education.ie/en/Publications/Inspection-Reports-Publications/
South Africa. Department of Science and Technology (DST) (2012). Framework for the promotion of excellence in a national network of science centre.
South Africa. Eastern Cape Department of Education 2015/16 – 2019/20 Five-Year Strategic Plan Vote No. 6 (2015). Eastern Cape: The Department.
South African Agency for Science and Technology Advancement (SAASTA). 2016. Science Engagement Highlights Report 2014-2015.

http://www2.saasta.ac.za/wpcontent/uploads/2016/01/SAASTA-Highlights-Report_DevV7_web.pdf
Spaull, N. (2013). South Africa's Education Crisis: The quality of education in South Africa 1994-2011. Johannesburg: Centre for Development and Enterprise. Retrieved January 3, 2018 from http://www.cde.org.za/images/pdf/South%20Africas%20Education%20Crisis%20N%20Spaul l%202013.pdf.
Spradley, J.P. (1980). *Participant observation*, New York: Holt, Rinehart and Winston
Stiggins, R. J., Arter, J. A., Chappuis, J., & Chappuis, S. (2004). *Classroom assessment for student learning: Doing it right, using it well.* Portland, OR: Assessment Training Institute.
Suleiman, S., Bakar, M.D., Arshad, M. Y., Ismail, Z., & Abdullah F. A. P. (2013). *Promoting scientific and technological literacy among the postgraduate students at Faculty of Education UTM*. *2nd International Seminar on Quality and Affordable Education (ISQAE 2013).* Faculty of Education, Universiti Teknologi Malaysia.
Sünbül, A. M. (2010). *Öğretim İlke ve Yöntemleri* (4. Baskı). Konya, Türkiye: Eğitim Kitabevi.
Sumarni, W. (2013). The strengths and weaknesses of the implementation of project based learning. A Review. *International Journal of Science and Research, 4*(3), 478-484.
Taber.S. (2011). Constructivism as education theory: Contingency in learning and optimally guided instruction. In J. Hassaskhah (Ed.). *Educational Theory* (pp. 39-61). New York: Nova Science Publishers, Inc.
Tamir, P. (1988). Subject matter and related pedagogical knowledge in teacher education. *Teaching and Teacher Education, 4*(2), 99-110. doi:10.1016/0742-051X(88)90011-X
Taole, M. J. (2013). Educators' conceptions of the curriculum review process. *International Journal of Education*, *5*, 39–46.
Tashakkori, A., & Teddlie, C. (1998). *Mixed Methodology: Combining Qualitative and Quantitative Approaches*. CA: Sage.
Tashakkori, A., & Teddlie, C. (eds) (2003) *Handbook of Mixed Methods in Social and Behavioral Research*. CA: Sage
Tashakkori, A., & Teddlie, C. (2006). *Validity issues in mixed methods research: Calling for an integrative framework*. Paper presented at the annual meeting of the *American Educational Research Association*, San Francisco.
Tashakkori, A., & Creswell, J. W. (2007). Exploring the nature of research questions in mixed methods research. *Journal of Mixed Methods Research, 1*(3), 207-211.
Tashakkori, A., & Teddlie, C. (2010). *Sage Handbook of Mixed Methods in Social & Behavioral Research*. Thousand Oaks, CA: Sage Publications
Teddlie, C., & Yu, F. (2007). *Mixed methods sampling: A typology with examples. Journal of Mixed Methods Research, 1*(1), 77-100.
Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research. Integrating quantitative and qualitative approaches in the social and behavioral sciences.* London: Sage.
Terrell, S.R. (2012). Mixed Methods Research Methodologies. *The Qualitative Report*, *17*(1), 254-280.
The United States Centre for Education Statistics (2005). Retrieved December 2, 2016, from http://nces.ed.gov.

Timpany, G. (2011). *Structured vs unstructured questionnaires*. Retrieved December 12, 2017 from: http://www.survey.cvent.com/blog/customer-insights-2/structured-vs-unstructured-questions.

TIMSS (2003). International mathematics report. In IVS Mullis, MO Martin, EJ Gonzalez & SJ Chrostowski (eds). *Findings From IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College

Thomas, J. W. (2000). *A review of research on project-based learning*. Retrieved January 6, 2018 from http://w.newtechnetwork.org/sites/default/files/news/pbl_research2.pdf.

Toth, E.E., & dan Graham, W.V.U. (2016). Preparing scientifically literate citizens: pre-service teacher candidates' use of normative and logical thinking for critically examining news media. *Electronic Journal of Science Education. 20*(1), 1-17.

Turiman, P., Omar, J., Daud, A.M. & Osman, K. 2012. Forestring the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia Social and Behavioral Science, 59*, 110-116.

Tyler, R. (2007). *Re-imagining science education. Engaging students in science for Australia's future*. Australian. Camberwell: ACER Press.

Tweed, A. (2009*). Designing effective science instruction: What works in science classrooms*. Arlington, VA: National Science Educators Association Press.

Twenty First Century Science (2008). *Scientific literacy and curriculum reform.* Retrieved January 10, 2018 from http://www.21stcenturyscience.org/

Ugwuadu, O.R. (2012). Sex differentials in acquisition of science process skill among senior secondary biology students in Yola-South local government area of Adamawa State. *National Association of Science, Humanities and Educational Research Journal, 10*(1), 1-8.

United Kingdom. Department for Education (DfE). (2014) *Statutory framework for the early years foundation stage.* Retrieved February 16, 2018 from https://www.gov.uk/government/publications/early-years-foundation-stage-framework-2

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting qualitative descriptive study. *Journal of Nursing & Health Sciences, 15*(3), 398-405.

Vasilache, S. (2014). *Cross-cultural training and team work in health care: A volume in the advances in health care information system and administration (AHISA) book series.* USA: Medical Information Science.

Verbeek, M 2013 A guide to modern econometrics. 4th ed. Rotterdam School of Management. Wiley.

Wang, J., & Wen, S. (2010). Examining reflective thinking: a study of changes in methods students' conceptions and understandings of inquiry teaching. *International Journal of Science and Mathematics Education*. Retrieved December 23, 2017 from EBSCO. http://ejournals.ebsco.com/direct.asp?ArticleID=4F6CBAE4E3BBD1F0DC2A

Webb. P, (2009). Towards an integrated learning strategies approach to promoting scientific literacy in the South African context. *International Journal of Environmental & Science Education 4*(3), 313-334.

Wittrock, M. C. (1992). Generative learning process of the Brain. *Educational Psychologist, 27*(4), 531-541.
Wilkinson, D., & Birmingham, P. (2003). *Using research instruments: A guide for researchers.* London: Routlegde Falmer.
Woolnough, B. E. (1991). Setting the scene. In B. E. Woolnough (Ed.), *Practical science* (pp. 3-9). Milton Keynes: Open University Press.
White, R.T., & Gunstone, R.F. (1992). *Probing Understanding*. Great Britain: Falmer Press.
Yasin, R. M., Mustapha, R., & Zaharim, A. (2009). Promoting creativity through problem oriented project based learning in engineering education at Malaysian polytechnics: Issues and challenges. Paper presented at proceedings of the *8th WSEAS International Conference on Education and Educational Technology.* Retrieved January 18, 2018 from http://dokumenti.ncvvo.hr/Konferencije/Kongres/EDU15.pdf.
Yin, R.K. (2011). *Qualitative Research from start to finish*. New York: Guilford Press Publications.
Yin, R.K. (2013). *Qualitative research from start to finish.* New York: Guilford Press Publications.
Yore, L., & Treagust, D. (2006). Current realities and future possibilities: Language and SL-empowering research and informing instruction. *International Journal of Science Education, 28* (2-3), 291-314.
Yount, W.R. (2006). *Research design & statistical analysis in Christian ministry*, (4th ed.). Retrieved June 10, 2018 from http://www.napce.org/documents/research-design yount/00_Front_4th.pdf.10th June 2018].
Youssef, S., & Mohammed, C. (2016). Teaching strategies for developing scientific literacy and on students' achievement in biology. *Asro Journal of Education, 1*(1)*, 6-19.*
Zajkov, O., & Mitrevski, B. (2012). PBL: Dilemmas and questions! *Macedonian Physics Teacher, 48*, 1-11.
Zandvamari, A., & Daryapoor, E. (2013). Mixed methods research: A new paradigm in educational research. *Journal of Educational and Management Studies, 3*(4), 525-531.
Živković. S, (2014) .The Importance of oral presentations for university students. *Mediterranean Journal of Social Sciences, 5*(19), 468-475.
Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory and Practice in Language Studies 3*(2), 254-262.
Zulfiqar. S., Zhou. R., Asmi. F., & Yasin, A. (2018). Using simulation system for collaborative learning to enhance learner's performance. 5:1424678 Retrieved June 10, 2018 from https://doi.org/10.1080/2331186X.2018.1424678
Zhu, X., Ennis, C., Chen, A. (2011). Implementation challenges for a constructivist physical education curriculum. *Physical Education and Sport Pedagogy,16* (11), 83-99.
21st Century learning reference group (2014). Future-focused learning in connected communities. Retrieved September 10, 2015 from http://www.education.govt.nz/assets/Documents/Ministry/Initiatives/FutureFocusedLearning30May2014.pdf
Spradley, J.P. (1980). *Participant observation*, New York: Holt, Rinehart and Winston
Sandiford, P.J. (2015) Participant observation as ethnography or ethnography as participant observation in organizational research. In Strang, K.D. (ed) The

palgrave handbook of research design in business and management, (pp. 411-446), New York: Palgrave Macmillan.

LIST OF APPENDICES

Appendix A: Approval to conduct the study from DBE

Province of the
EASTERN CAPE
EDUCATION

STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecdoe.gov.za

Enquiries: B Pamla Email: babalwa.pamla@ecdoe.gov.za Date: 05 September 2017

Ms NA Mtsi

P.O. Box 876

Queenstown

5320

Dear Ms Mtsi

PERMISSION TO UNDERTAKE A DOCTORAL THESIS: EXAMINING EDUCATORS' STRATEGIES FOR PROMOTING SCIENTIFIC LITERACY AMONG GRADE 9 LEARNERS IN COFIMVABA

1. Thank you for your application to conduct research.
2. Your application to conduct the abovementioned research involving 120 educators and 50 learners from schools under the jurisdiction of Chris Hani District of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:
    a. there will be no financial implications for the Department;
    b. approval is received from the principal of the school selected (principals have a right to refuse permission to their schools);
    c. consent is received from parents of minor children;
    d. institutions and respondents must not be identifiable in any way from the results of the investigation;
    e. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;
    f. you will make all the arrangements concerning your research;
    g. the research may not be conducted during official contact time;

PGDP EASTERN CAPE

building blocks for growth

Page 1 of 2

Ikamva eliqaqambileyo!

h. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Strategic Management Monitoring and Evaluation;

i. your research will be limited to those institutions for which approval has been granted, should changes be effected written permission must be obtained from the Chief Director: Strategic Management Monitoring and Evaluation;

j. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis.

k. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.

l. you are requested to provide the above to the Chief Director: Strategic Management Monitoring and Evaluation upon completion of your research.

m. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.

n. you comply with your ethical undertaking (commitment form).

o. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Chief Director: Strategic Management Monitoring and Evaluation

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDoE.

4. The Department will publish the completed Research on its website.

5. The Department wishes you well in your undertaking. You can contact the Director, Ms. NY Kanjana on the numbers indicated in the letterhead or email nykanjana@live.co.za should you need any assistance.

NY KANJANA
DIRECTOR: STRATEGIC PLANNING POLICY RESEARCH & SECRETARIAT SERVICES

FOR SUPERINTENDENT-GENERAL: EDUCATION

Appendix B: Ethical clearance from university of Fort Hare

University of Fort Hare
Together in Excellence

ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	MAM061SMTS01
Project title:	**Examining educators' strategies for promoting scientific literacy among grade 9 learners in the Cofimvaba education district.**
Nature of Project	PhD in Education
Principal Researcher:	Nomxolisi Mtsi
Supervisor:	Prof K.J Mammen
Co-supervisor:	N/A

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: Research that includes children as per the official regulations of the act must take the following into account:

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
    - Any unethical principal or practices are revealed or suspected
    - Relevant information has been withheld or misrepresented
    - Regulatory changes of whatsoever nature so require
    - The conditions contained in the Certificate have not been adhered to

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office

The Ethics Committee wished you well in your research.

Yours sincerely

Professor Wilson Akpan
Acting Dean of Research

01 June 2017

Appendix C: Informed consent for educators

University of Fort Hare
Together in Excellence

Ethics Research Confidentiality and Informed Consent Form For Natural Science Educators

I am a PhD student at the University of Fort Hare conducting research regarding the topic: **Examining educators' strategies for promoting science learning and science literacy among grade 9 learners in a South African Rural Education District. I am asking you to participate in the study as an interviewee.** The study is focusing in finding out which strategies are relevant in promoting for learning science and promoting SL and will assist educators to enhance the teaching and learning of Natural Science in rural schools. The study is conducted in an attempt to understand the situation on the ground and seek ways to enrich the teaching and learning on Natural Science.

Please understand that you are not being forced to take part in this study and the choice whether to participate or not is yours alone. However, I would really appreciate it if you do share your thoughts with me. If you choose not take part in answering these questions, you will not be affected in any way. If you agree to participate, you may stop me at any time and tell me that you don't want to go on with the interview. If you do this there will also be no penalties and you will NOT be prejudiced in ANY way. Confidentiality will be observed professionally.

I will not be recording your name anywhere on the questionnaire and no one will be able to link you to the answers you give. Only the researchers will have access to the unlinked information. The information will remain confidential and there will be no "come-backs" from the answers you give.

The interview will last around forty minutes. I will be asking you a questions and ask that you are as open and honest as possible in answering these questions. Some questions may be of a personal and/or sensitive nature. I will be asking some questions that you may not have thought about before, and which also involve thinking about the past or the future. I know that you cannot be absolutely certain about the answers to these questions but I ask that you try to think about these questions. When it comes to answering questions there are no right and wrong answers. When I ask questions about the future I am not interested in what you think the best thing would be to do, but what you think would actually happen.

If possible, I would like to come back to this area once I have completed our study to inform you and your community of what the results are and discuss our findings and proposals around the research and what this means for people in this area.

INFORMED CONSENT

I hereby agree to participate in research regarding the educators strategies for promoting for learning science and promoting SL. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop this interview at any point should I not want to continue and that this decision will not in any way affect me negatively.

I understand that this is a research project whose purpose is not necessarily to benefit me personally.

I have received the telephone number of a person to contact should I need to speak about any issues which may arise in this interview.

I understand that this consent form will not be linked to the questionnaire, and that my answers will remain confidential.

I understand that if at all possible, feedback will be given to my community on the results of the completed research.

……………………………..
Signature of participant **Date**:…………………..

I hereby agree to the tape recording of my participation in the study

……………………………..
Signature of participant **Date**:…………………..

Appendix D: Informed consent for learners

University of Fort Hare
Together in Excellence

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR USE BY PARENTS/LEGAL GUARDIANS

TITLE OF THE RESEARCH PROJECT:

Examining educators' strategies for promoting science learning and science literacy among grade 9 learners in a South African Rural Education District.

PRINCIPAL INVESTIGATOR: Nomxolisi Alicia Mtsi

SUPERVISOR : Professor K. Mammen

Your child *(or ward, if applicable*) is being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff or doctor any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how your child could be involved. Also, your child's participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you or your child negatively in any way whatsoever. You are also free to withdraw him/her from the study at any point, even if you do initially agree to let him/her take part.

This study has been approved by the **University Research Ethics Committee at the University of Fort Hare** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?

In this research I would like to find out more about suitable strategies for learning science and promoting SL. Science is one of the most important subjects that promote the economic growth of the country.

- *Explain all procedures.* ***The study will use educators and learners as participants. They will participate voluntarily and ethical issues will be done for them before participating. The parents will sign consent form for their learners in order to participate in the study.***
- *Explain any randomization process that may occur.* ***Focus group of 03 learners will be used to ask questions.***
- *Explain the use of any medication, if applicable.* ***There will be no medication needed since the researcher will be using the free environment (school) only theory needed not practical.***

Why has your child been invited to participate?

Your child has been invited to participate in the topic natural science for instance how they learn the subject.

What will your responsibilities be?

Your responsibility as a parent is to give me permission to interview your child concerning the subject.

Will your child benefit from taking part in this research?

No individual benefit in the research, people who will benefit are learners and educators who will be able to use the suitable strategies for the subject and promote learning science and promoting for learning science and promoting SL.

Are there any risks involved in your child taking part in this research?

No risk and harm your child will experience during the research.

If you do not agree to allow your child to take part, what alternatives does your child have?

They will be assured that participation in the research will be absolutely voluntary and that they will be free to discontinue participation at any time, and they are free to mention that they will not participate.

Who will have access to your child's medical records?

The respondents will be told that their responses will remain anonymous, confidential and their names will not be written even if findings were published. The respondents and the school will be coded rather than being *referred to by names. The researcher and the supervisor are the ones who* **will have access to the information.**

What will happen in the unlikely event of your child getting injured in any way, as a direct result of taking part in this research study?

There is no possibility of the child getting injured while participating in this study.

Will you or your child be paid to take part in this study and are there any costs involved?

There will be no costs involved for you if your child does take part. Since the researcher will be using the community participants close to the school there will be no costs needed.

Is there anything else that you should know or do?

You should inform your family practitioner or usual doctor that your child is taking part in a research study**. N/A** (*Include if applicable*)

You should also inform your medical insurance company that your child is participating in a research study **N/A** (*Include if applicable*)

You can contact Dr…………….. at tel…………… if you have any further queries or encounter any problems.**N/A**

You can contact the Chairperson of the University Research Ethics Committee if you have any concerns or complaints that have not been adequately addressed by your child's study doctor.

You will receive a copy of this information and consent form for your own records.

Assent: Children with an age of 7 and above must give assent to participate in research

Declaration by parent/legal guardian

University of Fort Hare
Together in Excellence

By signing below, I *(name of parent/legal guardian)* …………………………………...……. agree to allow my child (name of child) …………………………………..… who is ………. years old, to take part in a research study entitled *(insert title of study)*

I declare that:

- I have read or had read to me this information and consent form and that it is written in a language with which I am fluent and comfortable.
- If my child is older then 7 years, he/she must agree to take part in the study and his/her ASSENT must be recorded on this form.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to let my child take part.
- I may choose to withdraw my child from the study at any time and my child will not be penalised or prejudiced in any way.
- My child may be asked to leave the study before it has finished if the study doctor or researcher feels it is in my child's best interests, or if my child do not follow the study plan as agreed to.

Signed at (*place*) ....…........……………. on (*date*) …………....……………….

Signature of parent/legal guardian Signature of witness

Declaration by investigator

I *(name)* Nomxolisi Alicia Mtsi…………………………………………….………. declare that:

I explained the information in this document to …………………………………..

I encouraged him/her to ask questions and took adequate time to answer them.

I am satisfied that he/she adequately understand all aspects of the research, as discussed above

I did/did not use a interpreter (i*f a interpreter is used, then the interpreter must sign the declaration below).*

Signed at (*place*) ....…........…………….. on (*date*) …………...………..

Signature of investigator

Declaration by interpreter (Only complete if applicable)

I *(name)* ……………………………………………..……… declare that:

I assisted the investigator (*name*) ………….……………………………. to explain the information in this document to (*name of parent/legal guardian*) ……...………………………….. using the language medium of Afrikaans/Xhosa.

We encouraged him/her to ask questions and took adequate time to answer them.

I conveyed a factually correct version of what was related to me.

I am satisfied that the parent/legal guardian fully understands the content of this informed consent document and has had all his/her questions satisfactorily answered.

Signed at (*place*) ....…........…………….. on (*date*) …………...……………….

Signature of interpreter……………….. Signature of witness………………………

Appendix E: Informed consent form for learner

University of Fort Hare
Together in Excellence

CHILD ASSENT TEMPLATE

PARTICIPANT INFORMATION LEAFLET AND ASSENT FORM

TITLE OF THE RESEARCH PROJECT: Examining educators' strategies for promoting science learning and science literacy among grade 9 learners in a South African Rural Education District.

RESEARCHERS NAME(S): Nomxolisi Alicia Mtsi

SUPERVISOR : Professor K. Mammen

What is RESEARCH?

Research is something we do to find new knowledge about the way things (and people) work. We use research projects or studies to help us find out more about disease or illness. Research also helps us to find better ways of helping, or treating children who are sick.

What is this research project all about?

Science is one of the most important subjects that promote the economic growth of the country. In this research I would like to find out more about suitable strategies for learning science and promoting SL.

The duration of your participation in this research project

The duration will be about one hour.

Why have I been invited to take part in this research project?

You are chosen to participate simply because you learn Natural Science in this school.

Confidentiality

Your name will not be required and the answers you give will not be given to anyone.

Who is doing the research?

University of Fort Hare
Together in Excellence

My name is Nomxolisi Mtsi. I am doing Doctor of philosophy at the University of Fort Hare.

What will happen to me in this study?

I will expect you to answer questions on how natural science and science literay is taught in your class.

Can anything bad happen to me?

Nothing bad will happen to you as a result of participating in this study.

Who else is involved in the study?

Two other learners from your class are participating in the study.

Can anything good happen to me?

There are no personal benefits for you for participating in the study.

Will anyone know that I am in the study?

No one will know that you participated in the study since your name will not be used.

Who can I talk to about the study? You can contact me, Ms N. Mtsi or the Principal of your school.

What if I do not want to do this?

You are free to refuse to participate in the study even if your parents have agreed to for your participation. You can decide to withdraw from the study at any time and nothing bad will happen to you.

Do you understand this research study and are you willing to take part in it?

YES NO

Has the researcher answered all your questions?

YES NO

Do you understand that you can pull out of the study at any time?

YES	NO

Sign here________________________ Date________

Appendix F: Questionnaire

QUANTITATIVE DATA COLLECTION

As the PhD candidate at University of Fort Hare, it is a requirement of the degree to collect data from the participants. The topic is "Examining educators' strategies for promoting science learning and science literacy among grade 9 learners in a South African Rural Education District. The data collected will assist the Department of Education to support educators in promoting science learning and science literacy in schools.

The researcher will interview natural science educators using quantitative method (questionnaires). The questionnaire is comprised of five questions; each question has a certain number of sub-questions to guide participants. Each participant (natural science teacher) is to respond as per instruction to all the sub-questions that are under each of the five main questions contained in the questionnaire. As the participant you are requested to respond to the questions to the best of your ability.

INSTRUCTIONS

Indicate your answers by writing **X** in the appropriate box, and also mark a cross **X** in the yes/no box:

NB: Comment by writing on the spaces meant for that.

SECTION A: EDUCATORS' BIOGRAPHICAL INFORMATION

1. Gender:

Male	Female
1	2

2. Age:

3. Highest academic qualifications

Educators Diploma	Bachelors Degree	Honours Degree	Master's Degree	Doctoral Degree	Other(Please state)

4. Position in the school

Subject teacher	Class Teacher	Head of department	Senior teacher	Deputy head	Principal

5. Teaching experience

0-2 years	3 – 5 years	6 -8 years	9 – 11 years	12 years and above

6. Experience in teaching natural science (NS)

Less than a year	
Between 1 and 5 years	
Between 6 and 10 years	

Above 11 years	

7. Employment status

Temporal	
Permanent	

Appendix F: Questionnaire:

PART: 1

You are requested to choose from one of the following options by marking a cross (x) in the column relevant to your responses for each indicated strategy.

Guiding research question: Which strategies do you use to teach natural science curriculum?

Strategies	Agree	Neutral	Disagree
Demonstration			
Problem solving			
Simulation			
Inquiry strategy			
Case study			
Lecture method			
Discussion method			
Brainstorming			
Modelling			
Role-playing			
Question and answer			
Presentation			
Project			
Investigation			

Mention any other strategy you use that are not in the list:

………
………
……

Mention any other strategy you know that are not in the list:

……
……
……

PART: 2

Guiding research question: What are the strengths and weaknesses of EACH of the following strategies in promoting science

Strategies	Strengths	Weaknesses
Demonstration		
Problem solving		
Simulation		
Inquiry strategy		
Case study		
lecture method		
Discussion method		
Brainstorming		
Modelling		
Role-playing		
Question and answer		
Presentation		
Project		
Investigation		

Strategies	**Promotes learner-centred approach**	**Promotes teacher centred approach**	**Allows higher order thinking**
Demonstration			
Problem solving			
Simulation			
Inquiry strategy			
Case study			
Lecture			

Discussion			
Brainstorming			
Modelling			
Role-playing			
Question and answer			
Presentation			
Project			
Investigation			

Write down any strength or weakness other than the ones mentioned in the options above:

Part 3

Research guiding question: Which of the following strategies are used to support educators to promote science literacy in schools? Respond to each row.

Strategies	Yes	No	Strength	Weakness
Cluster support (Sharing, discussing content) by cluster leaders.				
Workshops offered by District Office (content gap, assessment etc.).				
Workshops offered by non gorvemental organisations (NGOs).				
Support by Province (DoE)identifying challenges and motivating educators				
Awards given to educators for their hard work (DoE)				
South African Agency for Science a Technological Advancement (SAASTA) support science educators by giving them science resources.				
SAASTA also empower educators in content knowledge				
Educators work as groups to work on pace setters and prepare common exam papers etc.				
Science expo competitions whereby educators prepare their students to participate in science competitions				

Write down any other strategy which is used but not in the options above: ………
………
………

Write down the strength and the weakness of that strategy:

………
………
……

PART: 4

Research guiding question :Which strategies are most relevant in enhancing science literacy?

Strategies	Most relevant	Relevant	Not relevant
Demonstration			
Problem solving			
Simulation			
Inquiry			
Case study			
Lecture			
Discussion			
Brainstorming			
Modelling			
Role-playing			
Question and Answer			
Presentation			
Project			
Investigation			

Mention any relevant strategy that is not on the list above:
……
……
……

Justify your choice of:
Most relevant

……
……
……

Relevant

……
……
……

Not relevant

………
………
……..

PART: 5

Research guiding question: What strategies do educators use to assess students' science literacy?

Strategies	Agree	Neutral	Disagree
Assess using good principles of assessment			
Align the tasks using cognitive domain			
Conduct tests			
Give assignments			
Presentations			
Quizz			
Projects			
Experiments			
Debates			
Examinations			

Which other strategy would you use?...
....
....

Mention any other strategy which you know.
………
………
………

End of the questionnaire: Thank you for participating , I am very grateful.

Appendix G: Interview schedule for Natural Sciences educators

<u>SEMI-STRUCTURED INTERVIEW GUIDE FOR EDUCATORS</u>

INTRODUCTION

As the PhD candidate at University of Fort Hare, it is a requirement of the degree to collect data from the participants. The topic is "Examining Educator's strategies for promoting science learning and science literacy among grade 9 learners in a South African Rural Education District.. The data that will be collected will assist the Department of Education to support the Educators in promoting science learning and science literacy in schools. Kindly be as open and free as possible. Be assured that the confidentiality of information will be adhered to.

INSTRUCTION

Kindly respond to the questions honestly and express yourself as much as you wish. The researcher will clarify the questions if you do not understand.

EDUCATORS INTERVIEW SCHEDULE

INDIVIDUAL INTERVIEWS

STUDY GUIDING RESEARCH QUESTIONS	**INTERVIEW QUESTIONS**
Which strategies do educators use to teach natural science curriculum?	▪ What does the term strategies mean to you as a teacher? ▪ What does the concept scientific literacy mean? ▪ Which teaching strategies do you know? Mention them. ▪ Which teaching strategies do you employ in class? ▪ How do you employ the strategies mentioned above? ▪ Which teaching strategies are relevant in promoting scientific literacy? Prompt: Explain them and justify why you say they are relevant. ▪ Are you required to use the strategies by the CAPS document or is it your own choice? ***Prompt***: Clarify your answer and link it with specific aims if there are connections. ▪ What is the main purpose of the specific aims of CAPS N.S syllabus? ▪ Which specific aim promotes SL? (Emphasize more on science relevance to everyday life). ***Prompt:*** How do you integrate the specific aim with the content you teach? ▪ What are the benefits of incorporating teaching strategies when implementing N.S curriculum?
What are the strengths and weakness of these strategies	▪ What are the strengths of the strategies you practice in your class? ▪ What are the challenges of these strategies you use in your class? ▪ Concerning the strategies you employ in your class, do they promote constructivist approach? ***Prompt:*** Give a picture on how they promote learner centeredness. ▪ Are these strategies allowing higher order thinking skills? Prompt: How do you involve your students to apply higher order thinking skills? ▪ Do you have specific strategies that strengthen or promote SL? ***Prompt***: Mention them and examine in detail. ▪ Do you encounter any challenges in employing the strategies you mentioned above? Briefly explain the challenges? ▪ Are these challenges inhibiting your teaching and learning of N.S? Explain. ▪ Do you think promotion of SL is affected by these challenges? Clarify on how SL is affected.

	▪ Does the school management team assist you concerning the challenges you are facing? ▪ Are you involving the subject education specialist (SES) for advice on how to overcome the challenges you are facing?

How are educators supported to promote science literacy?	▪ What do you understand about the concept 'support' in your working environment? ▪ What support structures have administration put in place for science educators for effective teaching of N.S? ▪ Have you attended any workshop that will support science educators in implementing N.S effectively? ***Prompt:*** Explain how the workshop improved your teaching of N.S ▪ How does the district or Province support educators in the teaching and learning of N.S? ▪ Do you feel that sometimes there is lack of support from subject advisors? Explain. ▪ In your own understanding, are the educators clear about N.S content knowledge, explain? ▪ Do you consider yourself as an N.S specialist? ***Prompt***: Explain why you think you are the specialist of the subject. ▪ Do you believe that N.S content driven by a relevant pedagogy can enhance SL? Explain. ▪ What can be done by science educators to support each other to promote SL? ▪ Which support do you need urgently concerning N.S, in order to teach the subject effectively and promote SL?

Which strategies are relevant in enhancing science literacy?	▪ Are you aware of any strategies that are most relevant, relevant and not relevant in enhancing learning of science and promoting SL? Briefly list and explain them. ▪ What does technology integration mean to you? ▪ Share your experience on how you integrate technology in your teaching and learning of science. ▪ What types of technologies do you employ when teaching N.S curriculum? ▪ Are you aware of science inquiry strategy? ***Prompt:*** Explain how you apply the strategy in your teaching. ▪ Share your experiences on how you apply science inquiry strategy in your lesson. ▪ What do you understand about Predict-observe-explain strategy (POE)? ▪ Share your understanding in teaching using POE. ***Prompt:*** Give the clear picture on how you apply the strategy in your lesson. ▪ Concerning the three above mentioned strategies (SCIENCE INQUIRY, ICT, and POE) have you encountered challenges in applying them? Explain.

How do educators assess science literacy?	▪ What does the term assessment mean to you? ▪ What does it mean to integrate assessment and SL in your teaching? ▪ Are there any aspects you follow when assessing N.S SL? ***Prompt:*** Give clear details. ▪ Do you assess SL following the definition of assessment you mentioned above? ▪ Do you align your assessment using cognitive and affective domains (Direct instructions & small groups and role-playing & co-operative instruction)?

	Prompt: Explain how you include the domains in your assessment. ▪ Do you promote problem solving in your assessment? Explain? ▪ Are you allowing macro and micro strategies (active student engagement and higher order thinking skills) in the practical assessment you conduct in your class? ▪ Are there any challenges you experience when assessing N.S tasks? ▪ Is your assessment guided by good principles of assessment or your own creativity? ***Prompt:*** If it is your creativity it is based on what? If it is good principles of assessment, explain few principles. ▪ What do you suggest educators can do to assess both the content and practical in an effective way?

Appendix H: Lesson observation guide

Date: ______________________________

Time: ______________________________

Duration of lesson: ______________________

Grade: ____________________________

Topic:______________________________

Learning

objectives

Lesson Introduction:

Teacher Activities (Do they promote science literacy?)

Learners Activities and Relevant strategies that promote science learning and science literacy

Teaching and Learning Materials: Including N.S experiments

Teacher's pedagogical content knowledge and Constructivist class/ traditional class

Formative and Summative Assessment: Cognitive domains included

Achievement of learning Objectives including Technology integration

SUMMARY REPORT: Are the educators applying the three strategies effectively (Science inquiry, ICT, POE).

Appendix I: Interview schedule for focus group

SEMI-STRUCTURED INTERVIEW GUIDE FOR FOCUS GROUP

INTRODUCTION

As the PhD candidate at University of Fort Hare, it is a requirement of the degree to collect data from the participants. The topic is "Examining Educator's strategies for promoting science learning and SL among grade 9 leaners in a South Africn Rural Educatiom District." The data that will be collected will assist the Department of Education to support the Educators in promoting science learning and science literacy in schools. Kindly be as open and free as possible. Information provided by you during these interviews will be treated as confidential and used solely for the research purposes.

INSTRUCTION

Kindly respond to the questions honestly and express yourself as much as you wish. The researcher will clarify the questions if you do not understand.

LEARNERS INTERVIEW SCHEDULE

INDIVIDUAL INTERVIEW WITH LEARNERS (FOCUS GROUPS)

STUDY GUIDING RESEARCH QUESTIONS	**INTERVIEW QUESTIONS**
Strategies used by educators to teach Natural science (N.S) curriculum	▪ How does your science teacher introduce natural science lesson? ▪ How do you learn N.S in class? ▪ How does your teacher involve you in the lesson? ▪ Are you participating when the teacher is teaching? Prompt: Explain how you participate in the lesson. ▪ Do you work as groups when the teacher is teaching?
Strengths and weaknesses of these strategies	▪ Does your teacher teach you in a way that makes science learning fun? Prompt: What is it that your teacher do to make science learning fun and enjoyable? ▪ Do you enjoy science lesson? Prompt: If you do not enjoy, what is the problem? If you enjoy it, explain what makes you enjoy the lesson.
	▪ Give other activities that you do during the science lesson. ▪ Do the activities allow you to apply problem solving skills and critical thinking? Explain how you apply the skills. ▪ Which challenges are you facing when doing these activities? Prompt: How do you think these challenges can be solved?
The support you get to promote science literacy	▪ Do you get support from your parents and peers at home concerning N.S teaching? Prompt: What kind of support do you get? ▪ Do you get support from your N.S teacher when you encounter problems concerning the content? Explain what kind of support. ▪ Are you working together as students to support each other in difficult chapters? Prompt: How do you assist each other? ▪ What do you think can be done by educators to make N.S learning fun?
Strategies that are relevant in enhancing science literacy	▪ Do you use technology gadgets in science lesson? Prompt: Explain how you include technology in your lesson? ▪ What do you understand about the concept "technology integration"? ▪ Does your teacher allow practical activities to be done when implementing N.S curriculum? ▪ Do you participate in the following strategies in class: demonstrations, simulation?
Assessment concerning science literacy	▪ Give types of assessment used by your teacher in class, both formal and informal. ▪ Mention challenges that you face in both formal and informal science task. ▪ Are there any activities you do in class where you assess yourselves in groups or individually? ▪ Does your teacher give you feedback after the assessment?

END OF THE INTERVIEW: Thank you for participating and taking your time off your busy programme to respond to my request

Appendix J: Language editing certificate

20 Neale Road

Berea

East London 5241

R Thomas

30 November 2018

TO WHOM IT MAY CONCERN

CERTIFICATE OF LANGUAGE EDITING

TITLE OF THESIS: EXAMINING EDUCATORS' STRATEGIES FOR PROMOTING SCIENCE LEARNING AND SCIENCE LITERACY AMONG GR 9 LEARNERS IN A SOUTH AFRICAN RURAL EDUCATION DISTRICT

Student : NOMXOLISI MTSI

Student number : 200901232

Supervisor :Prof. KJ Mammen

Degree : Doctor of Philosophy(Education), Faculty of Education, University of Fort Hare

I confirm that the above thesis was checked for language and the suggestions for improvement have been implemented.

R Thomas

(MA- English)