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The use of science process skills by Grade 11 Physical Science Learners: A case study of two High schools in Gauteng Province, South Africa

CHAPTER ONE
Introduction to the Study

1. Introduction

Science process skills have been emphasised as part of science learning for more than a century (DeBoer, 1991). Science process skills (SPS) are the "tools that individuals or learners use to attain information about the scientific world and order this information" (Oxford Encyclopaedia Science Dictionary, 2010, p.178). Osborne and Freyberg (1985) describe science process skills as involving; identifying a problem, framing hypotheses, making valid predictions, identifying and defining variables, designing an investigations, gathering and analyzing data and presenting findings that are supported by the data. In many parts of the world, the use of science process skills is an integral part of science learning at the high school level. In South Africa, learner abilities to use science process skills are an integral part of the Physical Science education curriculum (Department of Basic Education, (DoBE), 2011). While this is so, the Gauteng Department of Education Examiner's Reports for 2011 and 2012 point out that examination questions requiring application of science process skills are poorly answered by Grades 12 candidates (GDE, 2012). Murphy (2009) recommends use of science process skills as a key element of credible scientific assessment systems. This is so because they aid effective conceptualization of new scientific concepts by learners. Ongowo and Indoshi (2013) support this assertion when they suggest that science process skills are very useful in the design and building of scientific facts, for Physical Science at school level.

Given the problem of poor use of science process skills mentioned above, this study investigated the extent to which these skills are utilized by high school Physical Science learners as well as some of the factors that contribute to poor utilization of the skills. Understanding these issues could go a long way towards improving Physical Science teaching and learning in South African high schools. Learner abilities to use science process skills form part of their scientific literacy (DeBoer, 1991). The development of learners' scientific literacy is a globally

acclaimed science education curriculum goal (Lankshear and Knobel, 2004; Bartos and Lederman, 2014). Osborne and Freyberg (1985) suggest that scientific literacy is important in today's technological world. Flores (2004) is of the view that science process skills (SPS) are essential for learners to live effectively in an increasingly scientific and technological world. Consequently, a study of learner use of SPS goes a long way towards determining the effectiveness of school science curricula in preparing learners as future citizens to function in society (Kolstø, 2001). In South Africa, the promotion of SPS has been advocated for a long time. For example, the National Curriculum Statement of 2002 (DoE, 2002) advocates the use of SPS as an essential part of teaching and learning of Natural Sciences. It has also been argued that learners with requisite SPS such as measuring, solving problems, and using thoughts and opinions (Nevin and Mustafa, 2010) are better equipped to think critically and learn science content effectively and productively. Consequently, understanding learner utilization of SPS can go a long way in promoting learner performance in Matriculation examinations. Grade 11 learners were chosen for this investigation mainly because they are the ones who proceed to write the Matriculation Examination. It has already been pointed out that poor utilization of SPS is a concern to the Department of Basic Education. Further, although studies (i.e. Johnson, Sadeck, Hodges, 2002; Rambuda and Fraser, 2004; Kazeni, 2005; Ambross, 2011) have been conducted in South Africa concerning science process skills, however, nothing has been explored and reported at Grade 11 level's usage of science process skills. Therefore, a study of this type was instituted to provide education curriculum planners, science teachers and science education stakeholders with feedback about usage of SPS. This enables formulation of SPS policies that are backed with facts concerning the extent of the usage of science process skills. In addition, a belief was generated that this study triggers a need for further study on science process skills.

1.1 Statement of the Problem

According to both the NCS (DoE, 2002) and the CAPS (DoBE, 2011) the key fundamentals through which science content and scientific processes should be cascaded to science learners is through effective utilization of science process skills. Despite this call by the Department of Basic Education (DoBE, 2011) and other stakeholders for science activities to be more inquiry driven, poor performance of learners in physical science at high school level could associated with poor utilization of science process skills continue (Gauteng Department of

Education examiner's reports (GDE, 2012; Department of Basic Education, 2011). However, it is interesting to note that the current CAPS curriculum in South Africa continues to place emphasis on learner mastery of science process skills. It is also heartful to note that Physical Science subject advisors also disclose that the utilization of science process skills, especially at Grade 11 level for Physical Science continues to be a problem. Thus, although the Department of Basic Education (DoBE, 2011) identifies science process skills as being vital in ensuring effective understanding of scientific phenomenon, for example, by the Department of Education's (2011) still show that their usage and utilization is still low. It is against this background that a study was instituted to try and understand the exact nature and extent of the the problem. This study therefore, focused on the use of science process skills by Grade 11 Physical Science learners. To help understand the nature of the problem the study investigated the utilization of science process at two schools, in Gauteng Province, South Africa. It was envisaged that these two case studies would help better understanding of the problem as well as provide insightful recommendations for policy makers and curriculum designers in South Africa. The major issues on which the study focused were: (1) investigating the extent of utilization of science process skills; and (2) unraveling some of the factors that hamper their usage by school learners. In order to achieve the purpose of the study the following research objectives and questions were formulated.

1.2 Aims of the Study and Research Questions

Accordingly, this study sought to evaluate the use of science process skills by Grade 11 Physical Science learners in two schools in Gauteng Province, South Africa. It also aimed to explore some of the factors associated with poor utilization of SPS by learners. To achieve these aims the following research questions were posed to guide the study:

1. To what extent are science process skills being utilized by Grade 11 Physical Science learners in the two science schools in Gauteng Province?
2. What are some of the factors associated with poor utilisation of SPS by Grade 11 Physical Science learners?

1.3 The South African Curriculum context

The current South African Physical Science CAPS curriculum is a replacement of Revised National Curriculum Statement Grades R-9, of 2002, and the National Curriculum Statement Grades 10-12 Government of 2003. The new Caps Document makes reference to the importance of science process skills when under its specific aims; it states (Department of Basic Education DoBE, 2011, p.13):

> The purpose of Physical Sciences is to make learners aware of their environment and to equip learners with investigating skills relating to physical and chemical phenomena, for example, lightning and solubility. Examples of some of the skills that are relevant for the study of Physical Sciences are classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, and inferring, observing and comparing, interpreting, predicting, problem-solving and reflective skills. [Department of Basic Education DoBE, 2011, p.13]

A closer examination of the above statement reveals that the skills mentioned here encompass the description of science process skills by Osborne and Freyberg (1985), who mention SPS as involving; identifying a problem, framing hypotheses, making valid predictions, identifying and defining variables, designing an investigation, gathering and analyzing data and presenting findings that are supported by the data. Additionally, the new CAPS document makes assessment of learner acquisition of these skills a critical curriculum requirement. Nevin and Mustafa (2010) regard SPS as the way of thinking, measuring, solving problems, and using thoughts and opinions. This entails that teachers and learners should be aware of the value of SPS development during Physical Science learning. Bulent, Mehmet and Nuran (2014) point out that it is important to investigate the extent of utilization of SPS by Physical Science learners so to accomplish the following:

- Allowing the Physical Science teacher know which process skills are essential for effective conceptualization of new scientific topics;
- Assist Physical Science teachers in knowing the nature of science process skills;
- Assist teachers in deciding on an effective teaching strategies;

- Improve the performance of learners in SPS and;
- Propose effective learning strategies for SPS.

1.4 Theoretical Framework

This study is guided by the theory on science process skills. The development of learners' SPS is found both in the history of science education (DeBoer, 1991) and the philosophy of John Dewey (1933). Dewey (1933) in particular emphasized the importance of learners' learning of science in processes similar to the real scientific world as opposed to the traditional "cookbook" approaches to teaching. Fundamentally, in addition to learning scientific ideas, concepts and principles, it is argued that learners of science must also develop abilities to; observe, infer, predict, measure, describe, classify, communicate ideas, and argue (Powell and Anderson, 2002). Furthermore, learners of science are expected to be able to; identify and control variables, formulate hypotheses, interpret data, use their five senses to gather information about objects and events and classify information. The American Association for the Advancement of Science (AAAS) report (AAAS, 2010) alludes to the idea that the elements of the scientific research endeavour can be taught using SPS. This is supported by Tobin and Capie (2010) who point out that Physical Science learners require well-articulated SPS in-order to enable them to learn and make valid scientific enquiry. Science process skills utilization therefore is a cornerstone of the scientific process and enterprise. As already noted, learner acquisition of a number of these SPS is fundamentally, a constitutive dimension of scientific literacy (Lankshear and Knobel, 2004; Bartos and Lederman, 2014). Bulent et al. (2014) point out the importance of SPS in learners' performance including in national examinations.

It is against the foregoing background that the study being reported here sought to determine the extent of use of SPS by South African Grade 11 Physical Science learners as well as determine some of the curriculum environment factors that are associated with learner utilization of the SPS.

1.5 Literature Review

The study of learner utilization of SPS is not a new research phenomenon. Research on learner utilization of SPS is globally abound (see for example, Dillashaw and Okey, 1980; Bybee and DeBoer, 2001; Rambuda and Fraser, 2004; Fullan, 2007; Akerson, Cullen and Hanson, 2009; İkram, 2010; Bulent et al., 2014). This research generally shows as pointed out by İkram (2010) and Bulent et al. (2014) that learner acquisition and utilization of SPS can have profound effect on learner performance in science including in national assessments. Fullan (2007) following up on the work of İkram (2010) reports that acquisition of SPS at each stage of learning is important, for instance during entrance to primary or entrance to high school level. An ex-post facto design study done by Akinbobola and Afolabi (2010), for example, which analyzed the SPS in West African Senior Certificate Secondary School Physics examinations from 1998 to 2007, found that candidates showed a high percentage of lower order (basic) science process skills (63%) as compared to higher order (integrated) SPS (37%). These findings are in agreement with the Gauteng Department of Basic Education Examiner's Reports for 2011 and 2012 which say that examination questions requiring use of science process skills are poorly answered by Matric candidates (GDE, 2012). In general, the SPS studies emphasize that SPS are the fundamentals upon which the conceptual framework of scientific expertise is built.

In Chapter 2 of this research report, some of the studies related to learner utilization of SPS and factors associated with low usage of these skills are explored and discussed in detail. It is suffice to mention, however, that the role of SPS in enhancing learner performance still requires researching. In the next section of this chapter, the research methodology followed in this study is briefly outlined.

1.6 Research Design and Methodology

The major orientation of the study design and methodology followed for this study lies within the constructivist learning environment research paradigm (Fraser and Onwu, 2006; Fisher, Harrison and Henderson, 1999). Essentially, the premises upon which this methodological approach rests is that what learners and teachers alludes in responses to questionnaires and interviews can be taken as reliable indicators of the classroom scene and what happens in the classroom. The methodology for this study therefore assumed that what learners

and teachers say in responses to questionnaires and interviews can be used as reliable indicators of learner utilization of SPS. An important assumption in using the research instruments used for this study (Likert questionnaire for learners, teacher and learner interview schedules) was that both teachers and learners have an understanding of what SPS are. The adoption of the approach was based on the premises that in order for learners and teachers to provide information that would enable the study research questions to be answered validly; they would of necessity have an understanding of both the new South African Curriculum and what SPS are all about.

Thus, from learners' responses (n=50; 25 learners from each school) to a questionnaire, quantitative data was obtained pertaining to learner utilization of SPS. The teacher (n=4; two teachers at each school), and learner interviews (four per school), qualitative data was obtained which enabled the answering of both the research questions given above. The quantitative data obtained was analysed using an SPSS programme Version 22 and the qualitative data was analyzed using a combination of analytic induction and interpretive analysis (Gall, Borg and Gall, 1996; Lincoln and Guba, 1986; Cohen Manion and Morrison, 2000).

1.7 Chapters Organisation

Chapter 1: ***Introduction to the study***

This chapter presents an outline of the general background and contextual factors of the study. Accordingly, it outlines the purpose of the study including the research questions. The literature that is significant to this study was briefly reviewed, including and the theoretical framework informing and guiding this study. Ethical issues were also briefly discussed in this chapter.

Chapter 2: ***Theoretical Framework and Literature Review***

This chapter provides a detailed review of the theoretical framework and literature applicable to this study. Issues that are discussed include defining science process skills, learner utilization of science process skills, role of teacher on learner utilization of science process skills and factors associated with poor utilization of science process skills in South Africa.

Chapter 3: *Research Methodology*

In this chapter, the research design and the specific methods used in undertaking the study are outlined. The research instruments that are utilized, their relevance and administration procedures are also presented. The issues of validity and reliability regarding the research instruments and data collection techniques are also outlined.

Chapter 4: *Results and Discussion*

This chapter presents and discusses the findings obtained for this study. The results are discussed under the two research questions. The extent of utilization of science process skills and the factors associated with poor utilization of science process skills.

Chapter 5: *Conclusions, Implications and Recommendations*

This chapter describes and details the conclusions found from the study by responding to the two research questions which were meant to achieve the purpose of the study. Implications and recommendations are raised.

1.8 Chapter conclusion

This chapter outlined the rationale for the study. The research aims and questions for the study were stated. An overview was given of the theoretical framework and literature review that guided the study. The methodological design and approach were outlined. In the next Chapter the theoretical framework and literature review for the study are presented and discussed in detail.

CHAPTER TWO

Theoretical Framework and Literature Review

2. Introduction

This chapter provides the theoretical framework and literature review, which guided this study. It reviews the literature about characteristics, aspects, concepts and issues involving nature of science process skills within a secondary school science. Further, key aspects of how science process skills are related to teacher pedagogical content knowledge (PCK) were fleshed-out. This is based on the premises that in order for teachers to develop learners' science process skills they need to have adequate PCK in the area. Literature on the relevance of teaching science process skills as demanded by the South African School curriculum is also discussed. Within this effort, the curriculum changes which have been done in South Africa since independence in 1994 are highlighted. Furthermore, some methodological issues and some of the limitations and hindrances to development of learner science process skills are teased out.

2.1 Theoretical Framework

2.1.1 Science process skills

Osborne and Freyberg (1985) stated that swift advancement of humanity and crucial changes in the activities of humans in all spheres of life began in the 19th century. The advent of globalization of the 20th and 21st centuries, changes in modern technology, rapid global economic expansion and scientific advancement have resulted in an even greater demand for children right from the foundation phase to be equipped with science process skills (Dillashaw and Okey, 1980; DeBoer, 2001; Rambuda and Fraser, 2004; Akerson et al., 2009; İkram, 2010; Bulent et al., 2014). Since the 19th century science process skills have played and continue to provide a fundamental role for learner's future skills in the science and technological related workplace (Hofstein and Lunetta, 2004; Hodson, 2005). There exists a common ground concerning the stronger emphasis and inclusion of science process skills in the science curriculum of many world countries beginning from the 19th century (Hodson, 2005). Therefore, in this 21st century

in order to assist learners to discover new scientific facts and knowledge or solve problems, the South African Revised National Curriculum Statement (R-NCS) and Curriculum Assessment and Policy Statement (CAPS) and have recommended a stronger emphasis on basic science process skills since they form a backbone for all other integrated science process skills.

Researchers (for example, Hofstein and Lunetta, 2004; Hodson, 2005) have articulated that economic and technological advancement that began in the 19th century has triggered the use of scientific methods in curriculum process, curriculum theory and in all stages of curriculum development. This means that various scientific approaches that encourage utilisation of science process skills in high school have been adopted in the making and design of high school science curriculum. These approaches include:

- ✓ Scientific approach to assessment such as use of measurable processes which ensured assessment of science process skills;
- ✓ Language curriculum design has incorporated various scientific concepts such as skills of communication and materials to develop learner abilities to identify and solve issues.
- ✓ Science skills curriculum has adopted technical approaches of science process skills to plug loopholes and setbacks in technology development.

Scientific research including the study done by the National Research Foundation (NRF) (as mentioned in Ongowo and Indoshi, 2013) pinpointed that science process skills is one of the great tools that was used by scientists and science curriculum designers in shaping and structuring science information and facts on a nationwide and worldwide scale, over the last 100 years. To this end, science process skills have been displayed at various world platforms such in science fairs, technology firms, engineering divisions, assembly plants and medical laboratories.

Science process skills deals and covers the activities of materials interaction processes as well as in the synthesis of acquired information (Flores, 2004). Both the National Curriculum Statement (2002) and Curriculum Assessment and Policy Statement (DoBE, 2011) states that science process skills imply "…….cognitive activity of creating meaning and structure from new information and experiences, in other words, learning strategies used in the process of understanding a new scientific situation or in the presentation of scientific process". On a slightly

different note, other researchers (for example, Nevin and Mustafa, 2010) explain science process skills as techniques learners use when acting or doing science. Nevin and Mustafa (2010) further stated that science process skills is "…proficiency in using various aspects of science and are associated with cognitive investigative skills (Nevin and Mustafa, 2010, p. 30)".

According to the Curriculum Development Centre (CDC) website (CDC, 2015), science process skills could be categorized into two, that is, basic science process skills and integrated science process skills. Whereas, integrated science process skills consist of activities such as interpreting data, making hypotheses, operational definition, control variables, and experimenting; basic science process include skills such as communication, identification, measuring and observing. These skills should be assimilated and mastered for a science learner to be grounded on scientific concepts. This notion is strongly backed by Murphy (2009) who alluded that learners can achieve intellectual thinking in integrated science process skills that can propel them to be future talented scientists or future science experts.

The practice and techniques of science process skills are the vital channels and corridors through which both high school science learners and scientists gather data, test hypothesis, conduct and verify experiments, discover new technology and formulate results. These profound science activities are critical to both learners and organizations to deduce scientific meaning and progress. Thus, science process skills enable science learners to develop a deeper science understanding and stimulate use of essential scientific data or facts in resolving problems.

This research was necessitated and driven by the introduction of new Curriculum and Policy Assessment Statements (CAPS) from 2012 to 2014 in South Africa within the secondary science curriculum. For Physical Science learners in Grade 11, the introduction of CAPS meant a detailed teaching and learning schedule, greater use of science process skills and introduction of new topics that needed a strong foundation of the processes of science. The key major aspect that was identified in both the NSC and CAPS for Physical Science was to produce Physical Science learners who are well grounded in science process skills. To this end, the CAPS Physical Science document (DoBE, 2011, p 8) stated that:

"The National Curriculum Statement Grades R-12 aims to produce Physical Science learners that are able to:

- identify and solve problems and make decisions using critical and creative thinking;
- work effectively as individuals and with others as members of a team;
- organize and manage themselves and their activities responsibly and effectively;
- collect, analyze, organize and critically evaluate information;
- communicate effectively using visual, symbolic and/or language skills in various modes;
- use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
- demonstrate an understanding of the world as a set of related systems by recognizing that problem solving contexts do not exist in isolation", (DoBE, 2011, p 8)

This shows science process skills are vital attributes that learners should possess in order to effectively learn Physical Science, conceptualize new science concepts and be successful in Physical Science examinations (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004).

2.1.2 Teacher understanding of science process skills

According to several science education researchers (for example, Dillashaw and Okey, 1980; King, Shumow and Lietz, 2001; Vhurumuku, 2004; Kazeni, 2005) effective scientific learning approaches by science teachers should consist of practical demonstrations, use of simulations, experimentation, use of visual teaching aids and use of scientific argumentation. In this respect, the CAPS curriculum requires Physical Science teachers to utilize both learner-centred and teacher centred teaching approaches, inquiry inclined investigations and practical's involving identification, design and synthesis of concepts to ensure learner mastery of science process skills (DoBE, 2011). This can also include other traditional approaches such as use of the chalkboard and talking. When teaching and cascading science process skills to science learners; teachers should demonstrate an outstanding mastery of key concepts about SPS and demonstrate aptitude and attention to detail. Teachers are therefore integral and highly important in the development of learner's science process skills. This is so, because teachers are the ones directly

involved in developing learner's science process skills. Below is an optimum science teaching method model constructed and modified from the work of Edison (2001, p.156).

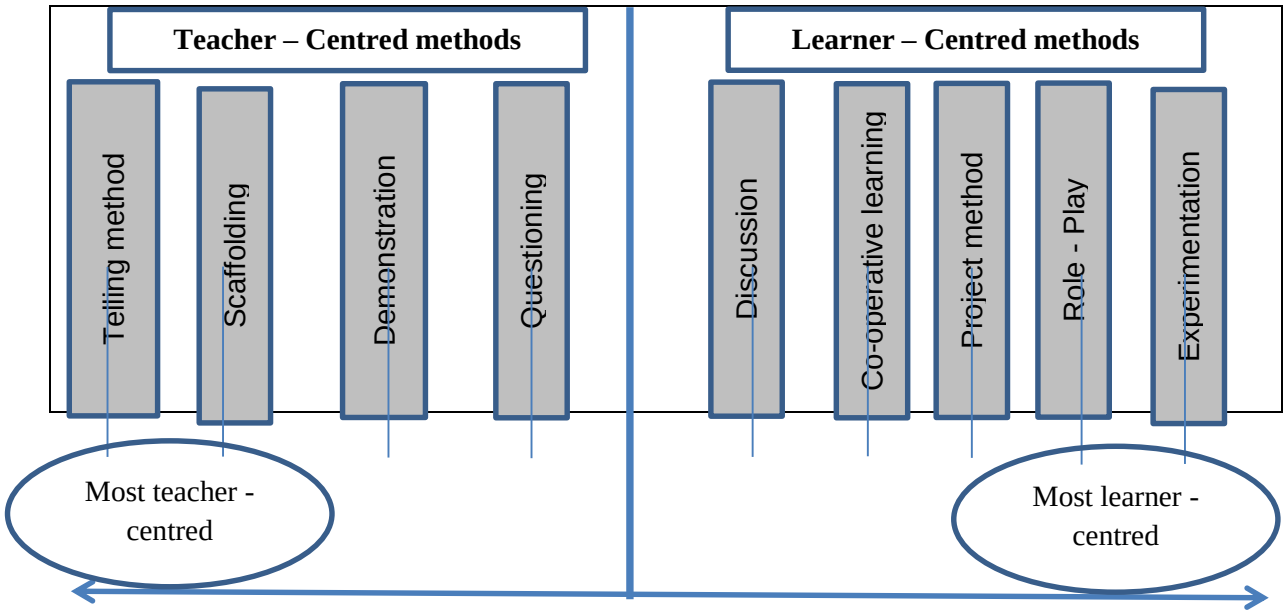


Figure 2.1: Model of Teacher and learner centred teaching methods

(Adapted and modified from Edison, 2001, p. 156**)**

The more effective a science lesson becomes the closer to the centre of the continuum. (Edison, 2001).The main reason for science teachers to be the main drivers of SPS, in the domains of this research is that science education is not necessarily about imparting knowledge and information, but includes a systematic way of handling and understanding the learner's environment. The rigor of science process skills that work and operate in science education can only be used to investigate and explore broader scientific phenomenon when teachers themselves are able to deal with happenings such as investigations and interpretations of science facts (Murphy, 2009). Therefore, in relation to this study, this implies that science process skills are normally applied and executed mainly by science teachers for revealing the realities of science effectively. To this end, science process skills are highly driven by science teachers to in-order for science learners to know and work with the world of science and technology in more detail.

Teacher educational training that ensures proper teacher mastery of science process skills normally includes courses such as Diploma in Science Education, Bachelor of Education in Sciences and Bachelor of Science in Science Education and other related courses (Murphy, 2009). Teachers who are trained in other fields of education such as humanity and social studies may find it challenging to properly deal with scientific investigations and issues relating to science process skills.

Further, Edison (2001) following up on the work of Piaget (1987) outlined that science education is a robust process of building and constructing science knowledge. In this way, educators play a leading role of guiding and enabling learners to build and construct scientific knowledge and not necessarily simply transferring scientific information. In this regard, teachers should make a good appreciable role when engaging learners in a dialogical manner and should try to stimulate learners to construct or build science process skills. Accordingly, good lesson comprehension conditions should comprise of variables such as good lesson structure, learner-centred teaching approaches and good lesson sequencing or pacing.

Concerning science teachers' development of pedagogical content knowledge (PCK) to teach science process skills, several teaching models and conceptualizations have been formulated. These PCK models seek to spearhead and promote the effective and efficient teaching and learning of science process skills (Grossman, 1990; Gess-Newsome, 1999; Bishop and Denley, 2007; Abell, 2008; Helmes, and Stokes, 2013). For instance, Cochrane, De Ruiter, and King (1993), whose model underscored the developmental nature of PCK in terms of teaching and learning science process skills; showed that PCK is an integration of other knowledge domains such as knowledge of subject matter, pedagogy, students and environmental content. The researchers of this model (e.g. Cochrane et al., 1993) suggested a synthesis and amalgamation or integration of the constituent components of PCK that enables effective learning of science process skills.

2.1.3 Learners' science process skills

Learners who study science learning areas such as chemistry, physics, life sciences and natural sciences are highly expected to utilize various facets of SPS such as calculations,

measurements, observations, interpretations and making experimental deductions (Flores, 2004; Noorden and Goods, 2004; Ongowo and Indoshi, 2013). On the basis of philosophical grounds it is not appropriate to consider science process skills as a mere science product, but should be taken as concept and means or channel through which science can be acquired effectively and efficiently by science learners (Flores, 2004).

In line with the standards requirements the Department of Education (DoBE, 2011) for advancement of conceptual and procedural understanding, Gott and Duggan (1995) designed a model (shown below) which is very useful for science curriculum as an outcome or product for a science learner's development of SPS. This model highlights what science process skills should achieve in the life of science learners. The model highlights thinking or cognitive processes in relation to its interactions with conceptual and procedural understanding through the usage of science process skills.

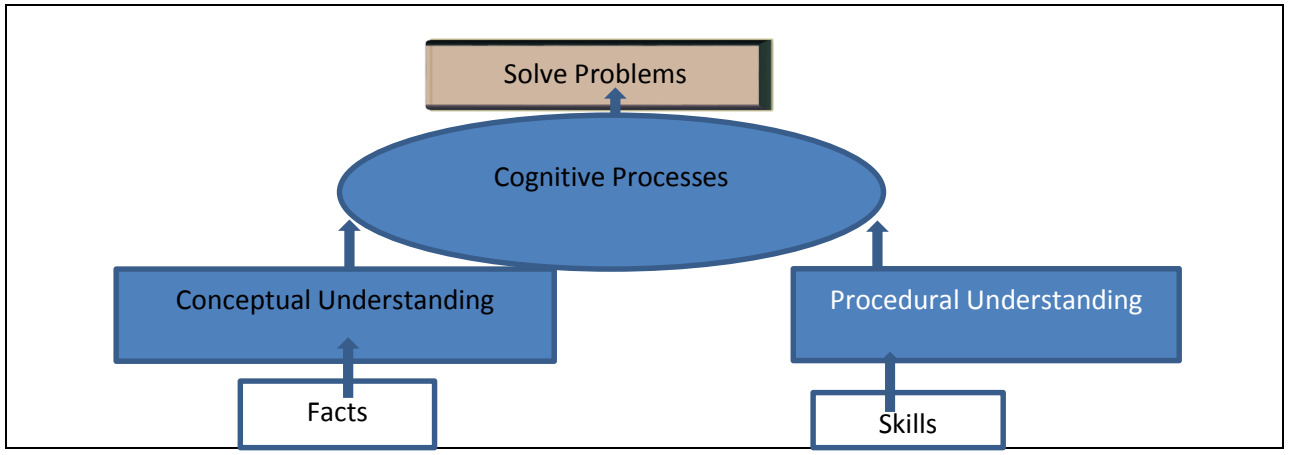


Figure 2.2: A science process skills outcome model

(Adapted from Gott and Duggan, 1995, p. 24)

Solving problems: The model can be applied to allow science learners to solve a range of problems through the usage of science process skills. These problems and issues include practical science problems, solving scientific phenomena, theoretical science issues, investigative problems and applied science difficulties (Gott and Duggan, 1995). As learners acquire new information and new mental structures with the help of SPS they will be able to excel in

conceptual and procedural understanding. This empowers them to solve even more challenging science problems.

Conceptual understanding and facts: According to the model of Gott and Duggan (1995), conceptual understanding was stated to be "…the understanding of ideas which are based on facts, laws and principles and which are sometimes referred to as substantive or declarative concepts". Examples of such understanding encompasses the ability of science learners to be able to apply concepts of science process skills in resolving problems and in dealing with topics like organic chemistry, chemical equilibrium, motion and energy.

Procedural understanding and skills: Procedural understanding involves interrelated activities that enable appropriate learning and construction of scientific steps (Rambuda and Fraser, 2004). This results in an action or activity being carried out by science learners. Procedural understanding requires a number of science process skills to be put together and enable such procedure to be carried out. This is necessary in carrying out scientific experiments, build a science model and compile or design a useful science product.

Cognitive processes: Cognitive processes enable science learners to be stimulated in their activities (Rambuda and Fraser, 2004). This causes efficient development of science facts, skills and concepts. Therefore cognitive processes should work together to enable conceptual and procedural understanding. These cognitive processes are strengthened through the usage of science process skills.

List of Science Process Skills: According to the NSC (DoE, 2002) essential science process skills are vital and crucial for learners to acquire relevant scientific abilities like making scientific conclusions, developing scientific materials and community development. These essential science process skills entails predicting, conducting investigations, recording results, collecting data, comparing, questioning and cascading findings.

The research instrument in particular the learner questionnaire used for this study sought to gauge how learners use each of the science process skills mentioned above. The science process skills that were probed and investigated in each of the research instrument included

measuring, calculations, identification, making hypothesis, communicating, analyzing and inferring.

2.2 Literature Review

2.2.1 Studies done on learner understanding and use of science process skills

Studies like the one conducted by Robertors and Sunders (1998) suggested that both integrated and basic science process skills can be introduced to learners starting from primary level using simple steps to allow primary learners to grasp. Their findings (e.g. Robertors and Sunders, 1998) strongly suggested that the appropriate level of introducing science process skills is in primary level to allow early skill transfer and future strengthening of science process skills. In tandem with research methodologies used for this study, Robertors and Sunders (1998) also used teacher interviews to generate research data for their research concerning the appropriate level to introduce science process skills in science learners. However, this study focuses on the extent of the usage of SPS at Grade 11 level, it is thus an appropriate level to check if the usage has now become effective and fortified given that the recommended level to introduce them has since lapsed (Robertors and Sunders, 1998; Rambuda and Fraser, 2004).

Another African study about science process skills on science learners was conducted by Ongowo and Indoshi (2013) in Kenya. Their study sought to determine the science process skills incorporated in the Kenyan Certificate of Secondary Education (KCSE) biological practical examinations for a period of 10 years. The research methodology that was used was the ex-post facto design. They analyzed contents of KCSE biology practical questions basing on 12 categories of science process skills. Ongowo and Indoshi (2013) found out that "The five most common science process skills identified out of the 12 examined in the study are observation (32.24%), communicating (14.63%), inferring (13.13%), experimenting (12.21%) and interpreting data (11.94%). The results also revealed a high percentage of basic science process skills at 73.73% compared to the integrated science process skills at 26.27%".

Both the NSC (DoE, 2002) and the CAPS (DoBE, 2011) values and have placed the science process skills such as predicting, investigations, and problem solving at the epicentre of teaching and learning the subject of Physical Sciences. This means that Physical Science classroom

activities such as facts conceptualization, scientific investigation, assessments and interactions are driven and informed by several science process skills. This implies that there is a need to research on various facets about SPS and this study has focused on the usage of science process skills.

2.2.2 Studies on teachers PCK and science process skills

Shulman (1987) studied that there are in general three broad categories of a teacher essential knowledge domains which are pedagogical content knowledge, subject matter knowledge and general pedagogical knowledge. In this regard, the way a science educator handles these types of knowledge bases have a strong bearing on the advancement of science process skills. A science teacher who has a strong mastery of these levels of knowledge will greatly assist learners acquire skills pertaining science processing such as recording, calculating, making inferences and experimenting. An educator of the calibre, that is who is versed with the knowledge of teaching science process skills will be a great asset to shape learners to develop scientifically.

Using both teacher interviews and a science process skills test score, Yakar (2014) studied the levels of teachers' scientific literacy that enables teachers to be able to cascade science process skills without difficulties. To this end, it can be concluded that science educators who do not display a strong mastery of science process skills will hamper the development of science process skills in their learners (Yakar, 2014). Further, Loveday and Bombay (2008) for instance queries what could be the outcome if science teachers do not have the relevant knowledge and skills to cascade science process skills. They noted that the outcome could be that learners will be impoverished and lack basic principles on the use of science process skills.

Another international study on science process skills was done by Bulent et al. (2014). They studied about the science process skills of elementary teachers in terms of some variables such as gender, seniority, working place and students' grades. They employed a quantitative study by administering a survey. The study population they used consisted of 58 elementary school teachers from Aegean region, Turkey. They also administered a SPS test for these teachers. The results revealed that integrated process skills for elementary teachers were not

sufficient. The table below show some of their results. This table shows that there was no significance difference between basic and integrated process skills in terms of elementary teachers' grades.

Table 2.1: ANOVA results of elementary school teachers' basic and integrated skill scores and overall SPS scores of SPSTFT regarding their students' class levels

(Adapted from Bulent at al., 2014 p. 31)

SPSTFT	Students' Grades	N	M	Std. Deviation	ANOVA result
Basic SPS	1st grade	48	12.00	3.75	F : 2.398 Sig: 0.070
	2nd grade	35	10.25	3.96	
	3rd grade	32	9.96	3.58	
	4th grade	43	11.37	4.07	
Integrated SPS	1st grade	48	12.47	5.21	F: 1.500 Sig: 0.217
	2nd grade	35	12.34	4.59	
	3rd grade	32	11.09	4.32	
	4th grade	43	13.58	5.63	

To this end, educators should be well equipped with both basic process skills and integrated science process skills. In addition, educators should know which process skills fit for which science topic and the corresponding appropriate teaching method. Yakar (2014) argues that teachers and learners should be able to effectively and efficiently categorizes which science process skills requires simple basic knowledge and which science skills requires procedural knowledge and also which need application of prior skills.

Many PCK models have alluded to the need for science teachers to master all science knowledge bases (Grossman, 1990; Gess-Nesome, 1999; Bishop and Denley, 2007; Abell, 2008; Helmes and Stokes, 2013). One of the PCK model, namely the PCK Summit Consensus model sought to consolidate other PCK models on the best way to deal with teacher's pedagogical content knowledge. This model emanated from a PCK conference that was held in 2012, where several researchers met to deliberate and achieve consensus on key aspects and PCK models.

The PCK consensus model was developed using Shulman's knowledge base as a starting point to indicate what teachers need to master such as classroom norms and student's needs.

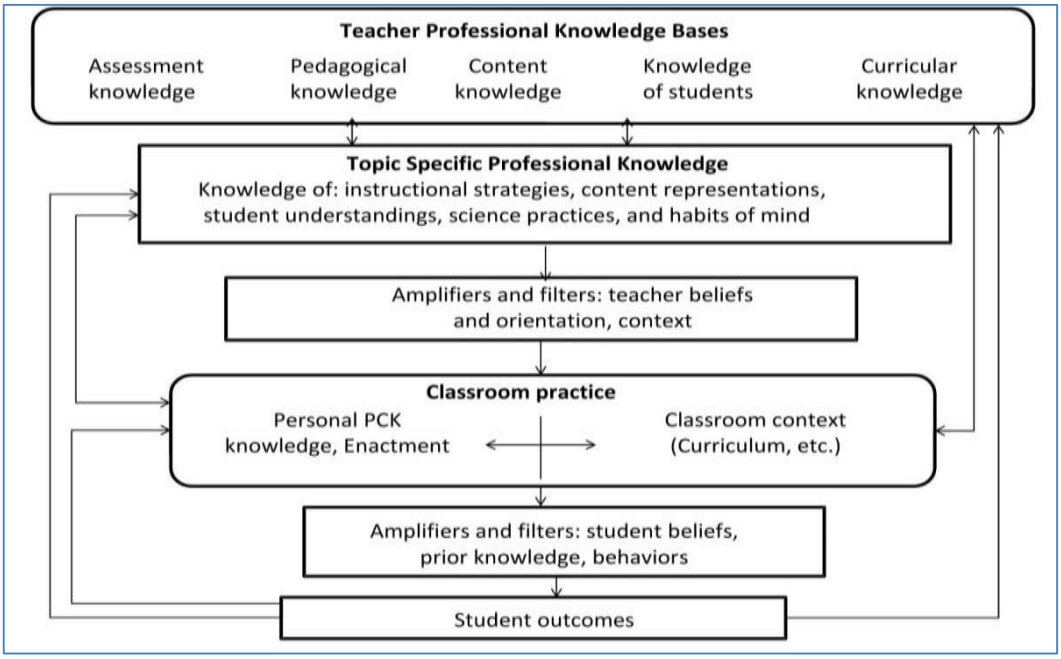


Figure 2.3: PCK Summit Consensus Model

(Gess-Newsome and Carlson, 2013, p. 51)

A closer look at the model above shows that students outcomes has been incorporated in a way that has not been done by other PCK studies and is thus highlighted as the major outcome of teaching and learning goals. In addition, there is an inclusion of a different set of amplifiers and filters between classroom undertakings and student understanding which included prior knowledge, student beliefs and behaviours. Further, the model uses the term PCK in special reference to classroom practice and is also termed personal PCK to reflect the individual tendency of PCK. Accordingly, personal PCK can be defined as 'Personal PCK is the act of teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes.' (Gess-Newsome and Carlson, 2013, p.16).

2.3 The South African curriculum context and science process Skills

It is of importance to note that since attaining independence in 1994, South Africa has implemented a range of curriculum policies which includes Curriculum 2005, National Curriculum Statement, NCS, Revised National Curriculum Statement, RNCS and Curriculum Adjustment and Policy Statement, CAPS (Murphy, 2009). Thus, scientific curriculum design and emphasis of science process skills depended on the focus of the curriculum making at that particular point of curriculum development (DoBE, 2011). In South Africa, teachers were subjected to multiple types of curriculum policies. Murphy (2009) noted that for the past 30 years various types of curriculum theories has been introduced at a given time, and changes have been made which incorporated scientific principles and a greater importance of the utilization of science process skills in science curriculum development and design.

After South Africa attained its independence in 1994, the Department of Education (DoE, 2005) under the direction of Minister of Education, Professor Naledi Pandor, pursued a vision by stating that science education had to play a role "to overcome the devastation of apartheid, and provide a system of science education that builds on democracy, human dignity, equality and social justice". In order to accomplish this, science curriculum had to be transformed. Murphy (2009) highlighted the important points in the transformation of curriculum and assessment that was pursued after the South African independence. This pursuit meant a greater utilization of science process skills in science subjects. The major points Murphy (2009) noted include:

- Establishment of a single, non-racial education and curriculum dispensation which valued scientific principles and scientific activities such as investigations and experiments;
- Major changes in the science assessment principles and methodologies which incorporated development of a learner's skills through utilization of science process skills;
- The upgrading and improvement of the education infrastructure to facilitate effective curriculum implementation and curriculum design.

According to Murphy (2009), the ANC government did much work to realize the transformation objective of science curriculum principles and education. Several scholars (e.g.

Rambuda and Fraser, 2004; Murphy, 2009) pinpointed that the government achieved many successes, although many plans and curriculum design were miscarried and not done effectively and others had to be re-designed.

Science process skills entails processes of interrelating with materials and utilizing gained information to achieve scientific goals. However, the NSC (2002, p. 54) considers science process skills as "cognitive activity of creating meaning and structure from new information and experiences: in other words, learning strategies used in the process of understanding a new situation or in the presentation of it". In addition, Bilgin (2006) stated that "…proficiency in using various aspects of science are associated with cognitive investigative skills (Bilgin, 2006, p. 30)". Thus, in South African science process skills should be taught directly to primary school children, however, with some level of intervention and training (DoBE, 2011). At secondary level in South Africa, science process skills are vital in the teaching and learning of Physical Science topics which are mainly:

- Matter and materials
- Chemical Change
- Chemical systems
- Mechanics
- Waves, Sound and Light

Bybee and Deboer (2001) on their various study on science curriculum pinpointed that post 1994 South African scientific curriculum brought with it an educational ideology and educational objectives which displayed greater precision and scientific principles. This triggered advancement of scientific variables across many educational theories and systems. This implies that the making of scientific curriculum incorporated various steps such as:

- ✓ Scientific methods in curriculum construction;
- ✓ Scientific methods in curriculum testing;
- ✓ Scientific methods in curriculum process;
- ✓ Scientific methods in curriculum theories;
- ✓ Scientific methods in curriculum products.

Furthermore, Flores (2004) noted that scientific curriculum makings of the Curriculum 2005, NCS, RNCS and CAPS incorporated the methodology of curriculum profiling and measuring in quantifiable terms of scientific and technical skills, attitudes, knowledge and systems. He went further to state that scientist curriculum making process is applicable to an individual learner or to an institution or to entire curriculum development systems. It can be deduced that the purposes and practices of scientific curriculum relies heavily on the curriculum theoretical framework and assumptions being made about the subject being studied. Further, according to the principles of the Department of Basic Education's guidelines (DoBE, 2011) on scientific curriculum making, science curriculum assessment refers to determining the rate of understanding and dealing with something, making an official valuation of given variables under study and determining the significance of issues under study. This science curriculum requires the testing and assessing of science process skills (DoBE, 2011).

Both the NCS (2002) and CAPS (2012) consider nature of science and science process skills to be interrelated since they both describes principles that governs elements of science which educators and learners need in-order to effectively comprehend scientific phenomenon and enquiry based learning. This enables creation of appropriate skills that promote learning of Physical Science in a South African secondary school. This also ensures a well-grounded environment for learning and conceptualizing science process skills. The following science process skills are strongly recommended and well-articulated by the Department of Basic Education as vital science products:

Observing and comparing: "These may involve the learner in noting details about objects, organisms and events with and without prompting by the teacher, noting similarities and differences, describing them in general terms, or describing them numerically" (NCS, 2002, p. 13). Researchers (for example, Robertors and Sunders, 1998; Bybee and Deboer 2001) suggested that comparing and observing is perhaps the most common skill of all the processes of science. It is also the primary or elementary way through which learners can acquire fundamental skills, facts and information about the impact of science skills (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010). It can be noted that the skills, facts or information that learners may glean from observing and comparing include curiosity, sound deductions and stimulation of further investigations and interpretations. Through

observing learners can begin to apply other science process skills without necessarily planning about it – such skills may include communicating, predicting and measuring.

Questioning: "Science is concerned with investigable questions, ones which can be answered by scientific enquiry (Flores, 2004, p. 38)." Scientific questioning entails ability to raise a question that stimulates scientific reasoning, formulation of relevant questions that stimulate scientific inquiry, re-structuring questions to carry scientific meaning and implications (NCS, 2002). Therefore, when learners acquire the ability to ask questions that can be scientifically investigated and enquired upon, it reflects that learners have recognized that there exists a gap in their understanding. When such kind of questioning arises then it implies that indeed science skills are being assimilated and utilized by such learners. This encourages learners to develop a huge interest in scientific inquiry and acquisition of new facts.

Predicting: Prediction in science can be referred to mean a reasonable conclusion on an enquiry before the actual investigation. For a prediction to happen there should be an enquiry. The enquiry can come in the form of a question such as "what is the outcome if…" This stimulates curiosity, observation, and creation of pre-existing responses that leads to a valid prediction. These are some of the activities that may happen during a prediction, that is a teacher may ask learners a scientific or enquiry based question and learners may give a valid response before the actual response is established through scientific enquiry.

Conducting investigations and collecting data: Through investigations and data collection, a learner carries out scientific procedures and follows a set of instructions that enables conclusion to be reached. Furthermore, science learners may follow stated rules on a worksheet, for instance, to set up laboratory apparatus or conduct an investigation and thereafter, record the data. In some cases, conducting an investigation can be a demanding task where science learners has to use other process skills like observations, collecting data, calculations, analyzing data and drawing conclusions in-order to solve a stated problem.

Recording results: "The ability for science learners to record results is a good practice for the upkeep of scientific ideas and also ensures future reviews. Recording can be done using a medium that can be saved and stored (Osborne and Freyberg, 1985, p. 41)". According to the

NSC (DoE, 2002) recording may be extensive and learners may have to make recordings on recording sheets which may include recording on tables, lists, diagrams, sentences, percentages and experimental figures. Educators may play a pivotal role to enable learners to master the recording of a particular subject or experiment. Learners are expected to know further recording steps once assistance has been given on initial recordings of a particular experiment or particular investigation.

Evaluating and communicating results: Evaluating and communicating findings is yet another important science process skill that learners should master in-order to be able to carry out tasks such as group work, report writing, making deductions, class presentations and examination write-up. This can also include situations where learners comment and make deductions on the work of other learners. Further, to ensure accuracy and fairness it is vital that learners make a reflection on the procedures and steps they used to conduct an experiment. This promotes evaluations and communication of findings in a more profound and accurate way. Communicating or cascading findings can be through a variety of ways, and these include posters, reports, diagrams, graphs, charts, actions, words, symbols, exam scripts and graphic means (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010). Another emphasize from the NSC (DoE, 2002) is that learners should have such abilities so as to report on the information they have found to their peers, seniors and community.

2.4 Factors associated with poor utilisation of SPS

Very few studies in the extant literature have been conducted concerning poor usage of science process skills (Rambuda and Fraser, 2004). However, there are many factors that have contributed to poor usage of science process skills. These include implications of the apartheid curriculum, shortage of resources and poor teacher training (Rambuda and Fraser, 2004).

Implications of the apartheid curriculum: According to Okrah (2002) the South African scientific curriculum making of the 1980-1990 decade was rooted with the systems of the apartheid era. This implies that it was a mostly skewed curriculum and normally referenced to a privileged white minority group. Further, it can be concluded that the apartheid era curriculum

system was driven by systemic means that was referred to as top-down by most scholars. According to scholars (e.g. Okrah, 2002) the only systemic curriculum assessment instrument during this time was the matriculation examination who types of curriculum assessment were not fully adequate, but lacking and biased. Okrah (2002) further stated that this period was having some tensions in the curriculum making criteria. In summary, the curriculum assessment systems was driven mostly through behaviourism theories and regarded as intrinsically and hopelessly flawed. These negative curriculum issues in the making and development of the South African science curriculum contributed to the present failure to adequately use science process skills (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010).

Poor teacher training: Loveday and Bombay (2008) discovered that one of the principal changes of the teacher training reform in the years immediately after transition (independence) was to unite the divided thread of teacher science process skill assessment and certification system into an integrated system. The NCS (2002) highlighted that the development of this teacher training aim can be traced from the National Educator Policy Investigation (NEPI) working group on Human Resource Development (HRD) in 1992 (NEPI, 1992). Further the NCS (2002) stated that "The goal was partly muted in the 1995 White Paper, for reasons to be discussed later on. It emerged strongly again with the passing of the South African Qualifications Authority (SAQA) Act No. 58 of 1995, and the establishment of a National Qualifications Framework (NQF) to advance principles of the scientific curriculum initiatives in teacher training". The lapse in teacher training that has since been resolved caused a negative development in terms of science process skills in schools. Further science teacher shortage in South African schools had a bearing in the development of science process skills (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010).

Lack of resources and technological issues: However, in the first decade of the millennium, science curriculum policy in South Africa started to move towards incorporating technology and certified science resource tools (CAPS, (DoBE), 2011). There existed resource shortage such as absence of laboratories and technological equipment in South African schools that caused a low usage of science process skills (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010).

2.5 Determining learner use of science process skills

For several studies conducted on science process skills, the most common research methodologies adopted utilized both quantitative and qualitative data collection methods which included administering a science process skill test, use of an interview schedule and a research questionnaire (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010). For instance, Bulent et al. (2014) administered a questionnaire on their study to determine the appropriate level to introduce science process skills in the school curriculum. This study used a learner questionnaire, interviews (both learners and teachers) and lesson observation. These methods had been validated and tested by other researchers (Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004; Nevin and Mustafa, 2010).

2.6 Chapter Summary and Conclusion

It was important to note that several issues concerning science process skills have been reviewed within the extant literature concerning this study about the use of science process skills. To this end, the researcher has managed to gain a bigger picture concerning the trend existing about science process skills. The next chapter deals with methodological issues.

CHAPTER THREE

Research Methodology

3. Introduction

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically (Frederick and Lori, 2011). This chapter details the methodology engaged to create and generate research data for this study on science process skills. This incorporates a description and a review of both qualitative and quantitative research methods that were used in this study. In addition, data collection instruments, sampling techniques, reliability and validity issues are dealt with in this chapter. Data analysis procedures and techniques that were employed are also explained. Lastly, ethical issues dealing with this research are outlined.

3.1 The Research Design

In general, a research design is referred to mean a strategy and blueprint of the steps involved in carrying out a research (e.g. Mouton, 2001). A research design is a wide-ranging plan for implementing a research strategy (Welman, Kruger and Mitchell, 2010). It specifies whether the study involves group or individual participants, makes comparisons within a group, or between groups, and also specifies how many variables are included in the study (Welman et al., 2010). A research design also includes details about how data is to be collected and analyzed. Research strategies are broad categories that classify study phenomenon and give a comprehensive picture of how the study is conducted (Frederick and Lori, 2011). Welman et al. (2010) describe three main types of research designs namely; exploratory, descriptive, and explanatory. For this study on science process skills an exploratory research design was employed.

An exploratory study assists researchers to develop concepts more clearly, establishes priorities and explores the variables under study in a more profound and far-fetched fashion compared to other research designs (Hatch, 2002). Further, according to Mouton (2001, p 12), an exploratory study is a valuable means of finding out, “what is happening; to seek new insights, to

ask questions and to assess phenomena in a new light". The purpose of this type of research is to progressively narrow the scope of the research topic and, consequently, paraphrase the problem (Hatch, 2002). Usually, when conducting an exploratory study, quantitative methods are employed. These can be followed with qualitative research methods (Fraenkel and Wallen, 2009). This allows researchers to not only explore generalities, but also to unveil various underlying factors concerning the phenomenon under study.

3. 2 Methodological Approach Used for this Study

As already noted for this study an exploratory research design was employed. This means that quantitative research methods were used. Qualitative data was also collected. This combined methodical approach can be described as one in which the researcher uses multiple methods of data collection and analysis. Following the survey approach, for this study, data was collected through the use of questionnaires to obtain quantitative data. Qualitative data is drawn from semi-structured interviews and lesson observations.

As noted in Chapter One, the major focus of this study was to examine the extent of the use of science process skills by Grade 11 Physical Science learners. The participants were from two Gauteng Schools which are given pseudo names School A and School B. Learners and teachers from these two schools participated in the study. In doing research of this nature, Fraenkel and Wallen (2009) advice of the importance of conditions of each case, as well as validly acquiring facts that assist in understanding characteristics under examination. Following this advice, firstly information about the two schools was obtained. This information became useful for purposes of administering the questionnaires to learners and the conducting of semi-structured interviews. Whilst the focus was on the learners, it was also important to interview their teachers so as to acquire a detailed understanding about some of the factors associated with the use and implementation of science process skills.

Quantitative questionnaire data was analyzed using a combination of descriptive and inferential statistics. Qualitative data was analyzed using an amalgamation of interpretational analysis and typological analysis (Hanuman, 2006). According to Hanuman (2006) typological data analysis entails using predetermined typologies to categorize text segments emanating from

theory, whilst interpretational analysis involves inferring meaning to data by deriving explanations and facts. Figure 3.1 summarizes the methodological framework that was employed.

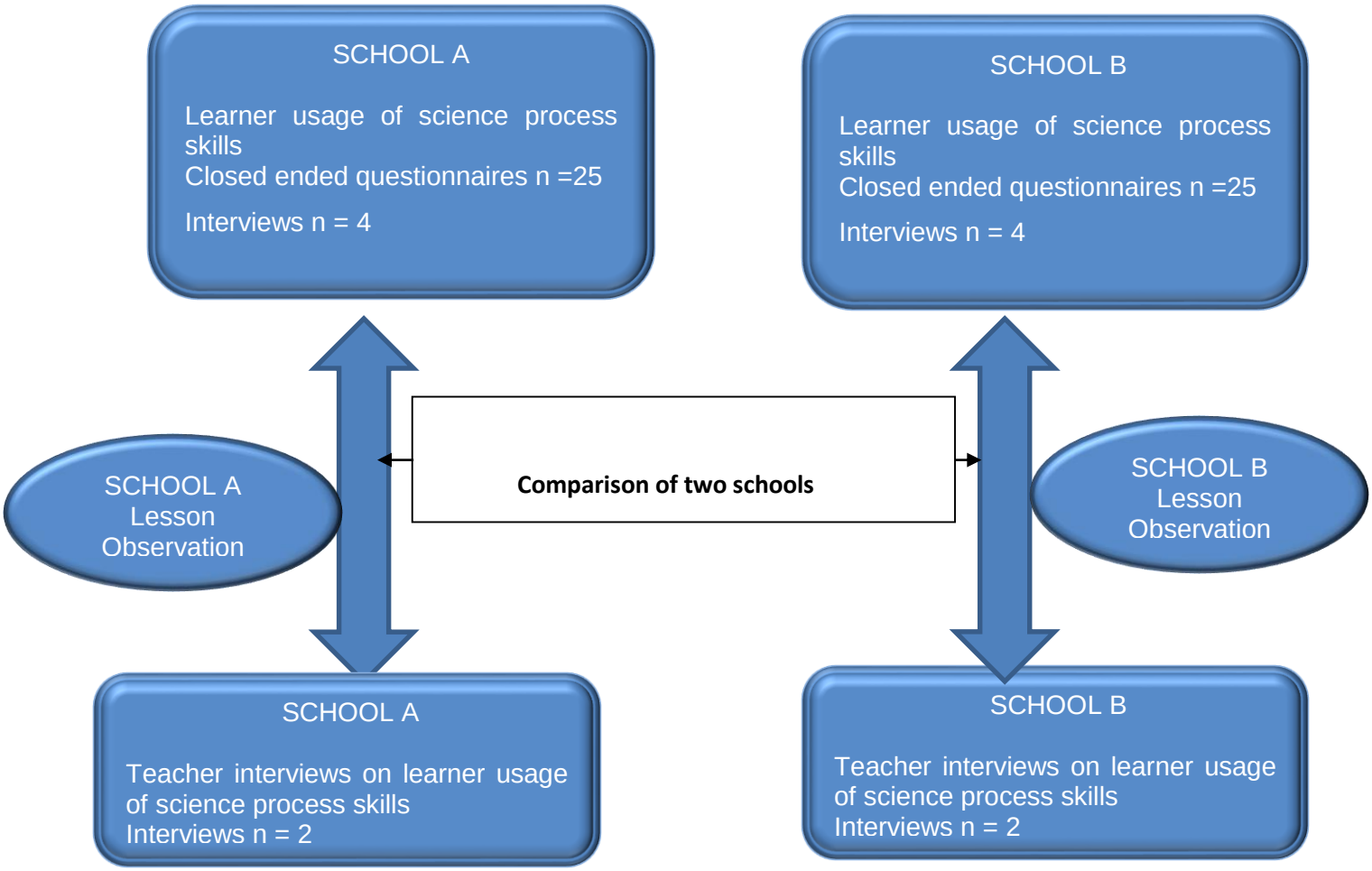


Figure 3.1: Summary of methodology framework

3.3 Sampling and participants

A population refers to all constituents of any clearly described group of people (Clifford, Michal and John, 2007). For any study, the target population is all the members of a group defined by the researcher's specific interest; in order for him/her to answer research questions. Gravetter and Forzano (2009) describe individuals in a target population as sharing some characteristic(s) of interest to the researcher. Aladejana and Aderibigbe (2007) describe members of a population as a group of people with common characteristics. Additionally, members of a

target population might share the same place of residence, be similar in gender, age and use of certain services. For this case study, the target population was Grade 11 Physical Science learners and their teachers in Gauteng Province, South Africa.

Whilst convenient sampling was chosen for this study because of mainly the limitations of time and financial resources, the researcher is aware of the different types of sampling techniques and their rationales. Gravetter and Forzano (2009) have warned that sampling must enable the researcher to obtain the best possible representation of the population. The representativeness of the sample can also depend on the sample size and the sampling technique used (De Vos, Strydom and Fouche, 2010). Consequently, when sampling it is important to take care of relevant characteristics such as age, race, gender and social class to provide valid reasons for making inferences about the population (Welman, et al., 2010) Representativeness of a sample can therefore be an issue. Along the same lines, Neumann (2003) cite factors such as heterogeneity of the population and the degree of accuracy in sampling as important.

3.3.1 Sampled Schools

The two Schools with pseudo names of School A and School B that were chosen were from the Gauteng districts, of Johannesburg Central and Ekurhuleni West, respectively. Convenient sampling was done of fifty Grade 11 Physical Science learners at these two schools. School choice was deliberately done such that the schools represented a dichotomous socio-economic category, that is, one school was a non-fee paying and the other school was a fee-paying school.

The reason or the rationale behind inclusion of both fee-paying and non-fee paying schools was to find out if some underlying factors (i.e. social, economic and resource availability trends) influenced the use and implementation of science process skills. Fee-paying schools are considered as modest schools which normally has all facilities and resources and in addition, children from these schools normally originate from middle to high income earning households. Non-fee paying schools are considered as less advantaged with children originating from low to middle income earning families. As noted, it was interesting to the researcher to find out if socio-economic conditions have an impact on how learners use and develop science process skills.

Both schools had a considerably large number of learners (72 learners in School A and 83 Learners in School B) in Grade 11 who were doing Physical Science.

3.3.2 Learner Sample

Fifty Grade 11 Physical Science learners (25 from School A, 50% of the sample) and 25 from School B, 50% of the sample) completed the questionnaire. Grade 12 Physical Science learners were deliberately excluded as they were busy preparing for National examinations. Grade 11 Physical Science learners were chosen to participate in the study since they are expected to have learnt application and use of science process at this stage (Rambuda and Fraser, 2004).

The sampling design used to select 25 learners from each of the two schools was non-probability sampling of conveniently and voluntarily asking interested Physical Science learners to present themselves for participating in the study. In both School A and B, more than 25 Physical Science learners presented themselves, however, only 25 learners from each school were selected based on first come first serve basis. The table below shows some demographic characteristics of the sampled learners.

Table 3.1: Some demographic characteristics of learner participants

Demographic Characteristics	**Sampled Physical Science Learners (Learner quantitative study= 50; learner interviews n = 10)**				
	School A		**School B**		Total
Gender	Male	Female	Male	Female	
Sample: quantitative study	13	12	13	12	50
Sample: learner interviews	2	2	2	2	8
Age	15- 18 years	15- 18 years	15- 18 years	15- 18 years	-
Subjects	Science stream (mathematics + Science + Geography + other subjects)		Science stream (mathematics + Science + Geography + other subjects)		
Socio-economic category	Low income category school		High income category school		
Fee status	Non- fee paying		Fee- paying		

Four learners from each of the participating schools were chosen for interviews (School A = 2 males and 2 Females; School B = 2 males and 2 Females). The four learners who participated in the interviews had also completed the questionnaire.

3.3.3 The Teachers

For the teachers, semi structured interviews were conducted with 4 Physical Science teachers, 2 from each school. One of the teachers who participated at School A was a male with 22 years teaching experience. The subjects he taught included Physical Science and Life Sciences. He held a Diploma in Education. The other teacher was female, with only 3 years teaching experience. She was teaching Physical Science and Geography. She held a Bachelor of Education degree.

At school B two male teachers participated in the study. The first had 16 years of experience teaching Physical Science and Mathematics. He held a Bachelor of Science with a Post Graduate Diploma in Education. The second teacher had 5 years of experience of teaching Physical Science and English. He held a Bachelor of Science Education degree specialized in Physical Science.

Basically the interviews were about the teachers providing descriptions on how their learners utilize SPS. The assumption was that since they interacted with the learners on daily basis they would know (Fraser and Onwu, 2006; Fisher et al., 1999). As alluded to the other reason for including educators in the study was that they were the one who were responsible for the development of science process skills for the Grade 11 Physical Science learners.

All the teachers who participated in the study had attended science cluster meetings (organized by their Education Districts) and were deemed to be familiar with both NSC and CAPS specifications about the need to develop SPS of learners during Physical Science lessons.

3.4 Research Instruments

This section presents the data collection instruments used in this study. These instruments are: Questionnaire on Learner Usage of Science Process Skills (Appendix A, adopted and modified from Bulent et al. (2014); Semi-Structured Interview Schedule for Learners (Appendix B); Semi Structured Interview Schedule for Teachers (Appendix C, adopted and modified from Rambuda and Fraser, 2004) and Lesson Observation Schedule (Appendix D).

3.4.1 Learner Usage of Science Process Skills Questionnaire

The questionnaire that was used (Appendix A) to evaluate the usage of science process skills was adopted and modified from Bulent et al. (2014). This is a five-point Likert scale questionnaire. Jupp (2006) describe a Likert scale as a summated rating scale use in measuring attitudes, which can be used to determine favourable or unfavourable attitude towards the concept of interest. According to Hatch (2002) the Likert questionnaire is the most widely used convenient instrument for measuring such constructs as the usage of science process skills. The items selected for this questionnaire have been piloted and validated for a long time by different researchers (for example, Rambuda and Fraser, 2004; Bulent et al., 2014) in studies of SPS and related issues. For this study, the questionnaire was divided into three sections namely: Section A-Demographic Information; Section B- Learner usage of science process skills; and Section C- on Impact of SPS on learner performance. In Section B of the questionnaire learners were required to indicate their responses along a five-point scale ranging from; *1= Rarely, 2 = Sometimes, 3 = Fair, 4 = Often to 5 = Always*. This procedure has been used successfully by Harlen (1999). Section C of the questionnaire was modified to take into context the South African situation in general and the Gauteng District in particular. Below is an example of two items on section B of the learner questionnaire.

Table 3.2: Example of items on learner questionnaire (i.e. items 5 and 6)

Rating questions about science process skills	Rarely	Sometimes	Fair	Often	Always
5. I can utilize and able to **IDENTIFY** important things or problems in Physical Science i.e. I can identify topics in Physical Science and able to work out some questions					
6. I can utilize and able to **CLASSIFY** the observed Physical Science features, e.g. able to classify scalar quantities and vector quantities or to classify acids and bases					

Validating the learner questionnaire for the South African context involved piloting it on some Grade 11 Physical Science learners at the schools who were not involved in the study. This enabled the researcher to be confident about the language suitability of the questionnaire items. Validating the learner questionnaire was also done with the assistance of my supervisor who okayed it in terms of its face and construct validity. Additionally, the questionnaire was also given to two fellow Masters students who are familiar with the South African curriculum to give their opinions on its face validity. Furthermore, the administered questionnaire was checked for internal consistency using the Kuder-Richardson formula 20 (KR-20). Computation of the KR-20 was found to be above 0.70. For this reason, it might be argued that the questionnaire that was used provides a valid measure of the construct under investigation (Engelhardt and Beichner, 2004). Suffice to mention that the researcher is aware of the fact that Kuder-Richardson Formula 20 (K-R 20) computations measures both validity and reliability aspects (Engelhardt and Beichner, 2004). Validity and reliability are vital criteria for ensuring the superiority and quality of a study, in this case instigating the use of science process skills (Hanuman, 2006). Therefore, for this study, it can be said that the instrument was tested for both validity and for reliability.

3.4.2 Learner Interview Schedule

A follow-up qualitative learner interview was administered using semi-structured interviewing technique. The interview schedule (Appendix B) that was used consisted of questions that were paraphrased in a way that stimulated further discussion about issues

involving science process skills. The semi-structured interview questions probed issues and perceptions detailing key issues about usage and hindrances on using science process skills. The questions that were used in the interview schedule were adapted and modified from previous similar studies (e.g. Rambuda and Fraser, 2004; Bulent et al., 2014). Questions were also posed during the interview process through prompts so as to get key factors that hinder the performance and utilization of science process skills by Grade 11 learners. Some of the questions that were used in the interview schedule are stated below.

- Which science process skills are you familiar with and which ones do you use mostly. Name them and explain
- How often do you use or apply these science process skills. Discuss
- To what extent do science process skills assist you to pass science examinations
- What are the possible hindrances on the use of science process skills by Physical Science learners

To check for the validity of interview questions, first the learner interview schedule was subjected to peer review during proposal presentations to check for content and language validity. Further, a Senior lecturer (in Science Education at the University of Witwatersrand) also reviewed the learner interview schedule content in terms of the content and environment of the Physical Science learners who were to participate in the study. This gave the researcher confidence in terms of content, face and language validity of the instrument. Further, to check the validity of learner interviews, 8 learners (who did not participate in the study) were given the platform to read and double check the information collected from interviews to find out if the interpretation of their statements needed to be altered or rephrased. Ignoring such due process could "interpretive framing of the learners stories of their experiences thus raise some grave concerns about the validity of the research", (Blignaut, 2005, p. 118).

3.4.3 Teacher Interview Schedule

The teacher interview schedule (Appendix C) used comprised six questions (from Rambuda and Fraser, 2004; Bulent et al., 2014). These questions asked teachers to provide information on the usage of science process skills by the Grade 11 Learners. Probing and prompting was done around these six questions. The questions were:

- How do you ensure science process skills are used by learners?
- How do learners copy with the use of science process skills? Discuss and Explain;
- To what extent do science process skills assist science learners to pass examinations? How much do they assist? Describe;
- What are the possible hindrances on the use of science process skills by Physical Science learners?
- On a scale of 1 to 5, How are you able to utilize and able to **IDENTIFY** important things or problems in Physical Science i.e. I can identify topics/substances in Physical Science and able to work out some questions and;
- On a scale of 1 to 5, How are you able to utilize and able to **CLASSIFY** the observed Physical Science features, e.g. able to classify scalar quantities and vector quantities or to classify acids and bases

As stated earlier, teachers were included in-order to corroborate their learners' usage of science process skills. As can be seen, the semi-structured questions used for interviewing teachers probed issues and perceptions on key issues about usage and hindrances on using science process skills. Other questions arose during the interview process so as to exhaust contextual key factors that hinder the performance and utilization of science process skills by the Grade 11 learners.

To check for validity, first the teacher interview schedule was subjected to peer- review during proposal presentations (done to peers at the University in a workshop). Further, the same Senior lecturer in Science Education who examined the learner interview schedule checked the teacher schedule for its content and construct validity. In this regard content, face and language validity were ensured.

3.5 Data Collection Procedure

The research data was collected firstly on learner questionnaire at School A, followed by data collection on learner questionnaire at School B. Secondly, after making interview appointments on different dates, the researcher went ahead to conduct interviews at School A for both learners and teachers followed by School B. Lesson observation was done lastly starting with School A, followed by School B. This was done over a period of three weeks. This allowed for ethical issues, questionnaire administration, interviews and lesson observation. With the exception of lesson observation, questionnaire administration and interviews were done after school lessons so as to avoid disturbing teaching and learning time.

Thus, as already discussed, the data collection techniques that was used for this study was administration of the learner questionnaire, teacher and learner interview schedules and lesson observation. These data collection procedures were deemed most appropriate and cost effective for the study (see for example, Bulent et al., 2014; Fullan, 2007; Rambuda and Fraser, 2004; Dillashaw and Okey, 1980; Bybee and DeBoer, 2001; İkram, 2010; Akerson et al., 2009).

3.5.1 Administration of Learner Questionnaire

According to Jupp (2006), administering questionnaires personally to individuals helps to establish rapport with the respondents. The administration of the questionnaires includes gaining access to the sample and attempting to maximise the response rate (Saunders, Lewis, and Thornhill, 2007). Whilst handing out the questionnaire the nature and objective of the study was explained to the respondents. In addition, they were also assured of the utmost confidentiality. Physical Science learners from the two schools were very enthusiastic after realizing that the study did not entail the identification of the respondent. All the questionnaires were completed in the presence of the researcher because all the learners were comfortable to complete the questionnaire in the presence of the researcher. At each School, learners took 20-30 minutes to complete the questionnaire. The researcher explained some key terms to the Physical Science learners to ensure that the questionnaire was well understood by the learners. Terminology for science process skills such as identify, calculate, experimenting were all explained to the learners

just before they completed the questionnaire. All the learners showed familiarity with the terms describing various science process skills.

3.5.2 Learner Interviews

As stated earlier, 4 learners from each school participated during learner interviews. The Physical Science teachers at each of the school assisted with selecting four learners who participated in the interviews. It must be noted that bias was given to top performing learners who could easily provide rich interview information. The researcher adopted probing strategies for soliciting usage of science process skills. For instance terms such as (i) poor use was substituted with (ia) low use; (ii) less poor use with (iib) low use; (iii) excellent use with very (iiic) very high use. This was done to enable both learners and teachers to provide vital information without being offended or exaggerating in any way. The interview recording technique that the researcher adopted was that of interviewing each learner whilst recording the results on a recording sheet. The reason the researcher used a paper recording sheet instead of audio or video was to exhaust and write the specific and well-structured responses from Physical Science learners (see for example, Bulent , Mehmet and Nuran, 2014; Fullan, 2007; Rambuda and Fraser, 2004).

3.5.3 Teacher Interviews

As described earlier, two Physical Science teachers from each of the two schools participated in the interviews. The recording technique adopted was similar to that of Physical Science learners described above. This involved interviewing the teachers and then recording on an interview response sheet. This was to allow teachers to comfortably exhaust issues about SPS without the interference of the thought that "I am being recorded". The responses were later transcribed and grouped into key themes for further analysis.

3.6 Data Analysis

Data analysis can refer to the conversion of raw data into useful information that will provide the most value to researchers (Jupp, 2006). The three types of data sets collected for this study was cleaned that is underwent data editing, validation, coding and categorization. In addition, the

researcher ensured that all relevant questions were answered and where possible, a follow up with learners was done to ensure completeness and consistency (Hanuman, 2006). The data from the questionnaire was not edited as it consisted of closed ended questionnaires that had all responses. In terms of blank responses, researchers (Hanuman, 2006) have evaluated that if 25% of items are not answered then the particular questionnaire should be discarded and not included in the data set (Hatch, 2002). Hatch (2002) suggests that blank responses can be handled through assigning the midpoint scale or ignoring the blank response or give a mean value of all the responses. The learner questionnaire achieved a 100% response rate.

3.6.1 Analysis of Learner Questionnaires

The data from learner questionnaire was entered into statistical analysis software, SPSS Version 22 (e.g. 2014 Model) using a coding system. Nominal variables were used for the Likert scale data to enable detailed analysis. The data was tabulated into frequency (number and percent) tables by running the SPSS tables tab. A frequency distribution is a tabular summary of data showing the number (frequency) of items (Hatch, 2002). Cross tabulation were also carried out (see chapter 4). Where necessary, measures of central tendency (i.e. mean, mode and median) were used to analyse the data from learner questionnaire. In addition, several questionnaire items were presented through graphs and percentage illustrations.

Variance which is defined as the sum of the squared deviations about the mean divided by the total number of values was used to analyse the extent of the variation between the use of basic and the use integrated process skills. Measures of relationship such as scatter plot, correlation coefficient and contingency table which concern the correlation between variables was used when the researcher wanted to determine the nature and extent of the relationship between SPS variables (Hanuman, 2006).

According to Hatch (2002) inferential statistics involves generalizing from a sample to the population from which it was selected. This includes parametric and non-parametric statistical tests (Frederic and Lori, 2011). Parametric statistics includes t-test and analysis of variance (ANOVA) was carried out determine whether the difference between the usage of two or more SPS means deviate from one another significantly or merely by chance (Moore and

McCabe, 2006). ANOVA was chosen because it can test if three or more means have a significant effect on a given variable. Further, ANOVA is applicable to any sufficient sample size and incorporate multiple factors and their interactions. The Chi-squared one of the most commonly used non-parametric statistical tests was also calculated so as to appropriately compared sets of data sets from teacher and learner interviews. (Hanuman, 2006:68).

3.6.2 Analysis of Learner Interviews

The data from learner interviews was cleaned and coded into similar themes. Similar themes were grouped into one broad categorization. This enabled meaning and key issues to emerge from the data. Further, the researcher noted that the interviews yielded an inductive meaning of the research results and underlying characteristics. The data was analysed whether it corroborated data from learner questionnaires and whether the data was unique or that is confirmed facts from other researchers.

3.6.3 Analysis of Teacher Interviews

The responses were later transcribed and grouped into key themes for further analysis. The key themes from teacher interviews were carefully categorized and related to the themes from learner interviews. This was done to see how teacher viewed learner usage of science process skills in relation to what learners considered good usage of science process skills.

3.6.4 Lesson Observation Schedule

A semi-structured lesson observation schedule (Appendix D) was also conducted to observe how learners and teachers use science process skills. One lesson from each of the two schools was observed. The lesson was on a science topic dealing with motion as this was the topic being done in schools at the time of the research. The reason why the researcher included an observation was to have a direct scrutiny on how usage of science process skills happens in schools and any hindrance, therefore (Rambuda and Fraser, 2004). The observation schedule dealt with specific science process skills during lesson instruction and was adopted using a set criterion from previous researchers (Rambuda and Fraser, 2004). The observation schedule was driven and guided by the following science process skills activities:

- Aim of science process skills;
- Source of science process skills;
- SPS used in classwork;
- SPS used during teaching and learning;
- SPS used in practical activities;
- Questioning techniques and SPS;
- How availability of resources affects usage of SPS;
- Reflections by the teacher;
- Learner responses and SPS;
- Commonly used science process skills;
- Frequency of usage of SPS

Spaces were created on the observation schedule for the researcher to make note and take recordings during the lesson. The results are presented in Chapter 4.

3.7 Ethical Considerations

Hanuman (2006) describes ethics as norms or standards of behaviour that guide moral choices about our behaviour and relationship with others. The ethics of the research design has important implications for the negotiation of access to people and organisations and the collection of data (Saunders et al., 2007). According to Creswell (2003) the goal of ethics in research is to ensure that no one is harmed or suffers adverse consequences from research activities. Unethical activities are pervasive and include violating non-disclosure agreements, breaking respondent confidentiality, misrepresenting results, deceiving people, invoicing irregularities and avoiding legal liability (Hanuman, 2006).

The researcher applied for ethics clearance at both the Gauteng Department of Education and Witwatersrand University. The ethics approval letters are attached in appendix E. Due processes of informing and seeking approval of principals, parents, teachers and learners of the intended study was done.

Both the educators and learners were informed in writing and consented to voluntarily participate in the study. They were informed that their names will not be published and that their

names will not be mentioned to the principal. They were given the assurance that research data will be treated confidentially and where necessary pseudonyms would be used.

3.8 Conclusion

The aim and objective of a research design is to ensure that the evidence obtained enables the researcher to answer the initial questions as unambiguously as possible. Having been provided with a theory the researcher needs to establish the evidence to test the theory in a convincing way. In research design, the issue of sampling method of data collection using questionnaire document analysis, data analysis are all subsidiary evidence to what needs to be established at the logical conclusion of the entire research study. The chapter ended with ethical considerations that were conducted for this study. The next chapter presents the results, discussion and interpretation of findings of the study.

CHAPTER FOUR

Results and Discussion

4. Introduction

This chapter presents the analysis and discussion of the results for the study. The presentation is organized around the two research questions posed for this study, which are:

- To what extent are science process skills being utilized by Grade 11 Physical Science learners in the two schools in Gauteng Province?
- What are some of the factors associated with poor utilization of SPS by Grade 11 Physical Science learners?

Within the effort of attending to the research questions the results are also presented and discussed following the sequence: (i) results from the questionnaire (ii) results from teacher and learners' interviews; and (iii) analysis of findings from lesson observations. The data analysis and presentation utilizes descriptive and inferential statistics. Data analysis is also interpretive (Gall et al., 1996; Cohen and Manion, 1994). Additionally, when discussing the results and interpretation of the findings, reflections on literature are made. Furthermore, the study's implications and recommendations are fleshed out. However, details about these including the conclusions are given in Chapter 5.

4.1 Extent of science process skills utilization by Grade 11 Physical Science learners

To compute SPS utilization percentage score levels (UPSL), first the extent of utilization of each science process skill was rated by 50 Physical Science learners based on a Likert scale section within the learner questionnaire (i.e. items 5 to 22). The Likert scale consisted of a range with *Rarely = 1, Sometimes = 2, Fair = 3, Often= 4 and Always =5.* In this study, those who rated a 3 (Fair) or above were considered to be utilizing SPS (Rambuda and Fraser, 2004; Ercan, 2007; Bulent et al., 2014).The average scores attained by the rating of 50 learners on the Likert scale range of 1 - 5 for each science process skill was generated using SPSS Version 22 software (see table 4.1 and 4.3 below). Thus, the descriptive statistics from questionnaire data shows that Grade 11 Physical Science learners attained a utilization percentage score level (UPSL) for basic

science process skills of 71.88% for School A (i.e. the average rating, in percent, of 25 learners on a range of 1, 2, 3, 4 or 5, which was 3.59 before percentage conversion, for instance 3.59/5*100). For School B, the UPSL for basic skills was 64.72%, that is, the average rating, in percent, of 25 learners on a range of 1, 2, 3, 4 or 5. This was 3.24 before percentage conversion (i.e. 3.24/5 *100). Thus, the overall utilization level for basic SPS was 68.3% (i.e. the average rating, in percent, of 50 learners on a range of 1, 2, 3, 4 or 5, which was 3.42 before percentage conversion) for both schools for basic science process skills.

Integrated science process skills show a utilization level of 46.23% (i.e. the average rating of 25 learners, in percent, on a range of 1, 2, 3, 4 or 5) for School A, and 42.12% (i.e. the average rating of 25 learners on a range of 1, 2, 3, 4 or 5) for School B. This yielded an overall an overall utilization score for integrated skills of 44.20 % (i.e. the average rating of 50 learners on a range of 1, 2, 3, 4 or 5) when both schools are considered. This is far from desirable. This trend showing a higher utilization score for basic than integrated SPS was a similar position found out by the study of Harlen (1999), Ferreira (2004), and Mutlu and Temiz (2013). This study thus provides an additional insight on SPS utilization level for Physical Science at Grade 11 level which had not been extensively covered by previous studies. To this end, a further study may be undertaken as to find out ways of making integrated science process skills as simple as possible to science learners.

To compare the skills utilization by the two schools a t-test was used. The Statistical software SPSS Version 22 was used to generate results for the t-test. The t-test was based on the comparison of the utilization percentage scores (i.e. combined average score for basic SPS and combined average score for integrated SPS) for School A and School B. According to the t-test ($F = 3.42$, $p \leq 0.05$), the difference of utilization between School A and School B for both basic and integrated science process skills was more significantly biased towards School A (i.e. F significance level = 3.42, favouring School A). An analytic approach similar to this one has been used in other studies on SPS (for example, Chan, 2002; Ercan, 2007; Nakiboglu, 2011). The results obtained here are in close agreement with similar analysis reported in the following studies: Chan (2002); Ercan (2007) and Nakiboglu (2011). However, with regard to the comparison of fee-paying school and non-fee paying school, this study provides a detailed picture for Physical Science at Grade 11 level as compared to other previous studies on SPS.

To compare the utilization between basic and integrated science process skills scores a second t-test was undertaken using SPSS version 22. According to the t-test ($F = 3.11$, $p \leq 0.05$), the difference of utilization between basic and integrated science process skills scores for both schools was more significantly biased towards basic skills (i.e. F significance level = 3.11, favouring basic skills). With the exception of a study by Ercan (2007), these findings are in agreement with those from previous studies (for example, Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011). These results show that there is a significance difference between utilization of basic and integrated science process skills in favour of basic skills. It could be as Ercan (2007) points out that learners start utilizing basic science process skills in early childhood, that is, Grades of 1 to 3. This could provide an explanation for this. Ercan (2007) recommends that from intermediate Grades of 4 to 7, science learners should begin to manifest some attributes of integrated science process skills. Thus, at Grade 11 level which was focused by this study, learners are expected to show high proficiency in utilizing science process skills (Miles, 2010). Obviously, teachers bear the responsibility to develop learners' science process skills (Fullan, 2007). It might be necessary to study the relationship between teachers' utilization of science process skills compared to learners' utilization of science process skills. However, the current study in line with previous studies (Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011) shows that to a greater extent there is a relative higher utilization of basic science process skills compared to integrated science process skills. The sections detail the extent of utilization of basic and integrated science process skills.

An overall rating and evaluation of seven basic science process skills was conducted on a Likert scale ranging from: *Rarely = 1, Sometimes = 2, Fair = 3, Often= 4 to Always =5.* Both schools performed above average in terms of usage of basic science process skills. However, School A obtained better utilization scores for basic science process skills on the "always" followed by the "often" rating category. Overall, basic science process skills mean score for School A, OBSPS-MS = 3.59). School B received the most utilization rating score for basic science process skills on the "often" category than on the "always" category. Overall basic science process skills mean score for School B, OBSPS-MS = 3.35. The table below summarizes the mean score averages. The OBSPS-MS was found as follows: firstly utilization of 7 basic

science process skills were rated by 50 Physical Science learners on a Likert scale section of the learner questionnaire on a range of *Rarely = 1, Sometimes = 2, Fair = 3, Often= 4 and Always =5*. Secondly, the mean score for 7 basic science process skills (see Figure 4.1) was calculated by adding the average rating scores for 7 basic science process skills and dividing by 7. Thus, the average score of 7 basic science process skills represented overall basic science process skill mean score (OBSPS-MS).

Table 4.1: Mean Averages of Usage of Basic SPS

	N	N	Minimum	Maximum	**Mean Scores**		Total N	Std. Deviation
	School A	School B	Statistic	Statistic	**School A**	**School B**	Sample	Statistic
Q5 Identify	25	25	2	5	**3.85**	**3.68**	50	.695
Q6 Classify	25	25	2	5	**3.14**	**2.73**	50	.632
Q7 Communicate	25	25	2	5	**4.34**	**3.86**	50	.561
Q8 Drawing Diagrams	25	25	2	5	**2.82**	**2.27**	50	.953
Q9 Compare	25	25	2	5	**3.64**	**3.36**	50	.570
Q10 Observe	25	25	2	5	**3.18**	**3.18**	50	.699

Table 4.1 shows that the mean scores for most basic science process skills was higher for School A than School B. Thus, it can be deduced that learners from School A are more proficient in utilizing basic science process skills compared to learners from School B. These mean scores were the average ratings for each basic science process skills that were found from the utilization rankings by the 50 Grade 11 Physical Science learners who participated in the study by completing the learner questionnaire. This study's outcome showing that learners are less proficient in utilizing integrated SPS than basic SPS is in agreement with the findings of studies by Burke(1996), Pekmez (2001), Rambuda and Fraser (2004) and Miles (2010).

In terms of the underlying factors behind the reason why learners especially from School B are less proficient in integrated SPS, research (for example, Oyoo, 2012; Msimanga and Lelliot, 2014) has shown that post-apartheid South African schools still grapple with economic

and educational disparities that have been generated by the apartheid legacy. These studies point out that black township schools have educational challenges, including proficiency in utilization of science process kills due to inadequately equipped learners. Oyoo (2012) further points out that these learners also face language and skills gap problems.

However, the fact that utilization of basic science process skills for both schools was above average is quite recommendable (Ercan, 2007). The results are not surprising. Studies (for example, Bybee and Deboer 2001; Rambuda and Fraser, 2004) show that for top performing learners the utilization of all basic science processes skills should be well above average. It is noteworthy that the lack of an always utilization for all learners on basic science process skills should trigger a determination by education policy designers and instructors to ensure that all learners incur high level of utilization of these skills (Bybee and Deboer 2001; Rambuda and Fraser, 2004).

4. 2 Questionnaire rating on basic science process skills

The specific percentage scores from learner questionnaires on the extent of utilization of each of the basic science process skills is shown below. As earlier stated, the frequency or extent of utilization of science process skills was evaluated using a Likert scale ranging from; *Rarely = 1, Sometimes = 2, Fair = 3, Often= 4 to Always =5.*

Utilization of basic SPS: identification

In-order to find out the extent to which identification was being utilized by Grade 11 Physical Science learners, all the 50 learners ranked how they utilized identification on item 5 of the learner questionnaire using a Likert scale point of 1 to 5 *with 1= Rarely, 2 = Sometimes, 3 = Fair, 4 = Often and 5 = Always*. Therefore, in terms of utilization of identification science process skill, learners rated their ability to identify or their frequency of engaging in "identification/identify related science activities" as follows; the highest number of learners, 32% (16 out of 50 learners) had an often utilization of identification, followed by an always utilization of 30% (15 out 50 learners) and then a fair utilization of 26% (13 out 50 learners). Although this was somehow satisfactory, about 12% (6 out of 50) indicated a sometimes utilization of identification. Studies by Burke (1996), Aydogdu (2006) and Miles (2010) show a similar trend

of a high utilization for most basic science process skills such as identification SPS. This implies that a small number of Physical Science learners took some time before engaging in science class activities requiring identification (Rambuda and Fraser, 2004).

Utilization of basic SPS: Classification

Classification science process skill's highest rating was an always rating of 42% (21 out of 50) followed by an often rating of 28% (14 out of 50) and sometimes utilization of 18% (9 out of 50). The utilization of classification was favourable with most of the learners indicating a relatively good utilization. The ANOVA table below shows the relationship between teacher reports of utilization and learner utilization of identification science process skill. The relationship between teacher report of utilization (Independent variable = X) and learner utilization of (Dependent Variable = Y) shows an F-value of 0.784, $p < 0.5$. This might mean that teacher own utilization of SPS has an impact on learner utilization of SPS.

Table 4.2: ANOVA for classification SPS: Teacher utilization versus learner utilization of SPS

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.116	1	0.116	0.784	0.773[b]
	Residual	66.384	48	1.383		
	Total	66.500	49			

a. Independent Variable: Q4TeacherUsage

b. Predictors: (Constant), Q6Classify

Utilization of basic SPS: Communication

The figure below shows the results for the utilization of communication science process skill.

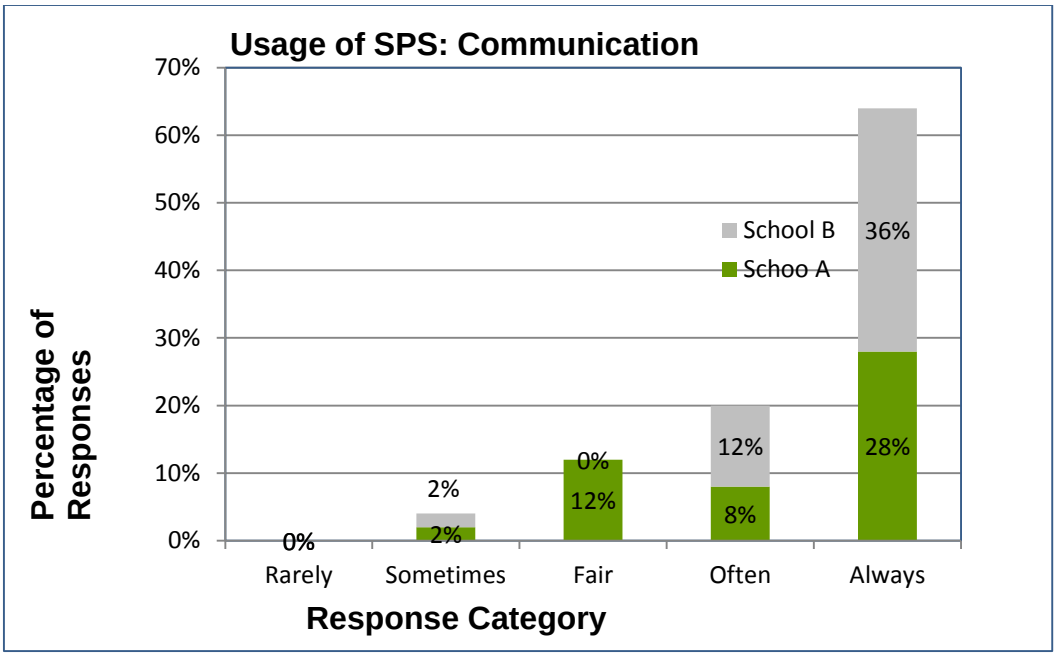


Figure 4.1: Usage of basic SPS (Communication)

Of all science process skills communication received the highest utilization rating, that is (64%) in terms of "always" utilization score. Both schools received the lowest rating (2% for School A and 2% for School B) for communication on the sometimes utilization rating category. Previous studies (for example, Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004) show that communication is one of the most fundamental science process skill that forms the foundation for utilizing all other science process skills. Other studies (for example, Oyoo, 2012; Msimanga and Lelliott, 2014) also note that communication and language are vital tools for learners to engage in science discourses. Thus, utilization of communication as a fundamental science process skill generates meaningful conceptual progression of essential science concepts. This study's outcomes provides a slightly more detailed picture of how utilization varies from one science process skills to the other, especially at Grade 11 level for physical science, which had not been profoundly dealt with in the extant literature.

Utilization of basic SPS: Drawing diagrams, observation and comparison

Drawing of diagrams received an always utilization score of 32 % (for example, School A with 22% and School B with 10%). Observation received an always utilization rating of 42 %

(for example, School A with 28%, School B with 14%). Comparison received an always utilization rating of 36 % (School A = 20% and School B = 16%). For all basic science process skills, both schools had no scoring on the "rarely" utilization category. However, for comparison science process skill, "sometimes" utilization rating category received a score of 22 % (with School A = 12% and School B =10%). This means that some learners are not excellent in terms of making comparison in science activities and in science discourses.

The results below address the extent of utilization of integrated process skills in detail. As stated earlier, a number of studies (for instance, Chan, 2002; Ercan, 2007; Nakiboglu, 2011) on science process skills showed a similar stance shown by this study that is most basic science process skills such as identification, comparison, drawing diagrams and communication incur a relative favourable utilization trend.

4.3 Overall utilization of integrated SPS between School A and School B

An overall analysis of five integrated science process skills was undertaken. Basically, both schools received a low utilization of integrated science process skills. The table below summarizes the mean utilization scores.

Table 4.3: Mean Averages of Usage of Integrated SPS

	N	N	Maximum	Minimum	**Mean Scores**		Total N	Std. Deviation
	School A	School B	Statistic	Statistic	**School A**	**School B**	Sample	Statistic
Q11 Predict	25	25	5	1	**2.24**	**1.91**	50	1.136
Q19 Construct Hypothesis	25	25	5	1	**2.50**	**2.10**	50	1.555
Q20 Experiments	25	25	5	1	**2.60**	**2.65**	50	1.525
Q21 Design Investigations	25	25	5	1	**2.36**	**1.78**	50	1.481
Q22 Relationships	25	25	54	1	**2.24**	**2.12**	50	7.350

In order to ensure an overall analytical picture of integrated science process skills, an overall integrated science process skill mean score (OISPS-MS) was calculated for both schools. The calculation of OISPS-MS was as follows, firstly utilization of five integrated science process skills were rated by 50 Physical Science learners on a Likert scale section of the learner questionnaire ranging from; Rarely = 1, Sometimes = 2, Fair = 3, Often= 4 to Always =5. Secondly, the mean score for 5 integrated science process skills (see Figure 4.3) was calculated by adding average rating scores for 5 integrated science process skills and dividing by 5. Thus, the average score of 5 integrated science process skills represented overall integrated science process skill mean score (OISPS-MS).

The results show that the mean scores for most integrated science process skill is higher for School A (i.e. Overall integrated science process skills mean score for School A, OISPS-MS = 2.38) than for School B (i.e. Overall integrated science process skills mean score for School B, OISPS-MS = 2.12). As discussed earlier, learners from School A (i.e. fee-paying school) are from high income earning families, whilst learners from School B (i.e. non-fee-paying school) are from low to middle income earning households. Thus, the results show that learners from School A are more proficient in utilizing integrated science process skills than learners from School B. The underlying factors associated with such disparities will be teased out in the sections below that discuss results associated with poor utilization of science process skills. Usage of integrated science process skill overall mean score when analyzing results of SPS was also incorporated in the studies of Ercan (2007), Miles (2010) and Jumanne (2012). In terms of position of the existing literature, most studies (see ,Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011) show that the overall utilization mean scores for modest schools is higher than for less privileged schools that are located in low income areas .

Generally, the usage of integrated science process skills for both schools is below average, that is, the mean score is less than 3 (i.e. below average utilization, 3 is the average score for a Likert scale point of 1 to 5). Studies (e.g. Bybee and Deboer 2001; Rambuda and Fraser, 2004) indicated that poor utilization of integrated science process skills is a good indicator for the lack of high scores in Physical Science examination tasks. Furthermore, low utilization of integrated science process skills also reflects that Physical Science learners struggle to comprehend and master vital science practical aptitudes that assist them to develop

competence to become future scientists, engineers and other scientific related careers. The lack of an above average utilization of integrated science process skills for some learners should trigger a determination by education curriculum designers and advisors to put measures for learners to begin to have a high level of utilization of integrated science process skills (Bybee and Deboer 2001; Rambuda and Fraser, 2004). Further, detailed results on ratings on the extent of utilization of each of the integrated science process skills are teased out in the upcoming portions.

4.3.1 Questionnaire rating on integrated science process skills

Utilization of integrated SPS: Prediction

In-order to find out the extent to which prediction and other integrated SPS was being utilized by Grade 11 Physical Science learners, all the 50 learners ranked how they utilized prediction on item 5 of the learner questionnaire using a Likert scale point of 1 to 5 (e.g. with 1= Rarely, 2 = Sometimes, 3 = Fair, 4 = Often and 5 = Always). Therefore, in terms of utilization of the science process skill of prediction, the highest number of learners indicated a "sometimes usage rating" of 48% (School A = 24% and School B = 20%) followed by fair utilization rating of 28% (School A = 16%, School B = 12%) and a rarely usage rating of 14 % (School A = 4%, School B = 10%). This indication of a rare utilization of an integrated science process skill by Physical Science learners implies that learners do not regularly conduct any science activities that warrant them to do, for instance, some prediction (Fullan, 2007). The figure below presents the results.

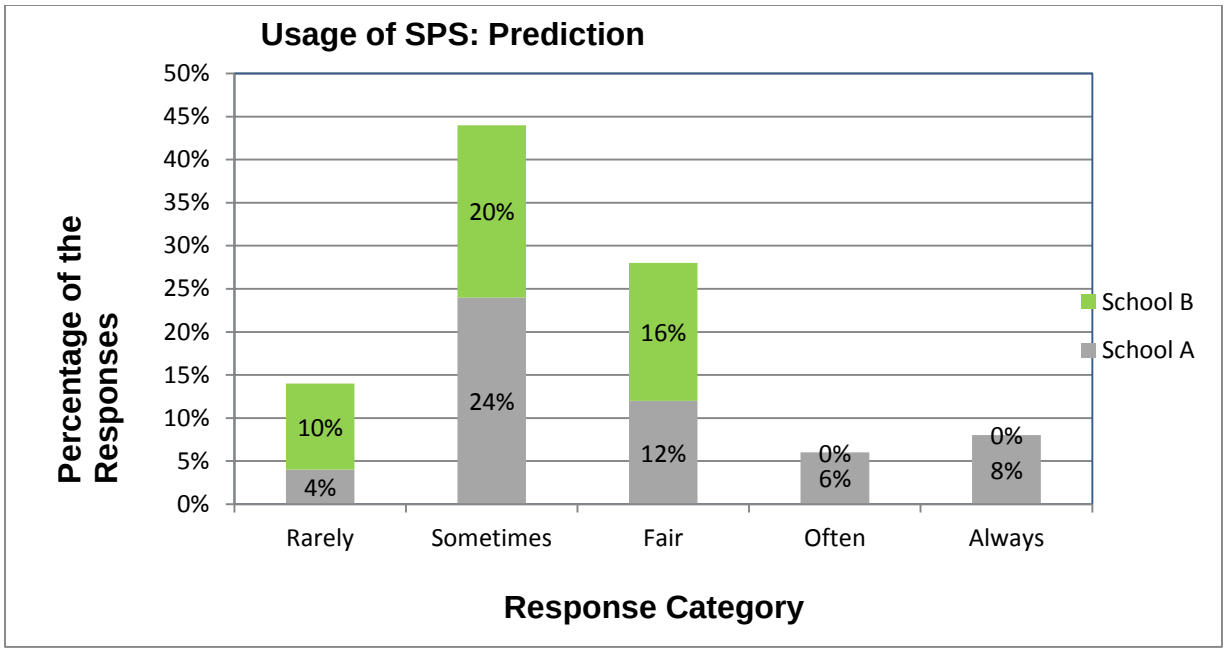


Figure 4.2: Usage of Integrated SPS (Prediction)

Fullan (2007) concluded that poor utilization of prediction science process skill could cripple the ability for learners to make informed decision in science activities. This impedes their forecasting abilities in predicting variable outcomes. Important science activities that may happen during a prediction process include, for instance, a teacher may require learners to conduct a scientific enquiry or estimate. This kind of task will require learners to provide a valid response before the actual response is determined using scientific investigations (Rambuda and Fraser, 2004). Usually the correct answer to such an estimate or inquiry is found experimentally or through an investigation.

Utilization of integrated SPS: Experimenting. For experimenting skill, the highest utilization rating for School B was on the sometimes usage category of 24%. Consequently, the major utilization category for School A was 18% also on the sometimes rating category. Scientific experiments entail ability to conduct practical enquiry that stimulates scientific reasoning, methods and procedures. In addition, scientific experiments provide variable results and determine how variables affect each other (Fullan, 2007). Furthermore, experimenting enables learners to attain the ability to conduct trials and to determine outcomes of scientific investigations. Realization and awareness that learners have an experimenting skills gap trigger a

greater need to master and improve learner practical skills by relevant school authorities (Fullan, 2007). When learners are equipped with experimenting skills, there is a generation of greater learner interest in scientific inquiry and acquisition of new facts. To this end, there is need for further research regarding on what ways does experimenting impact on the practical skills of Physical Science learners. The figure below depicts the results on the extent of utilizing experimenting science process skill.

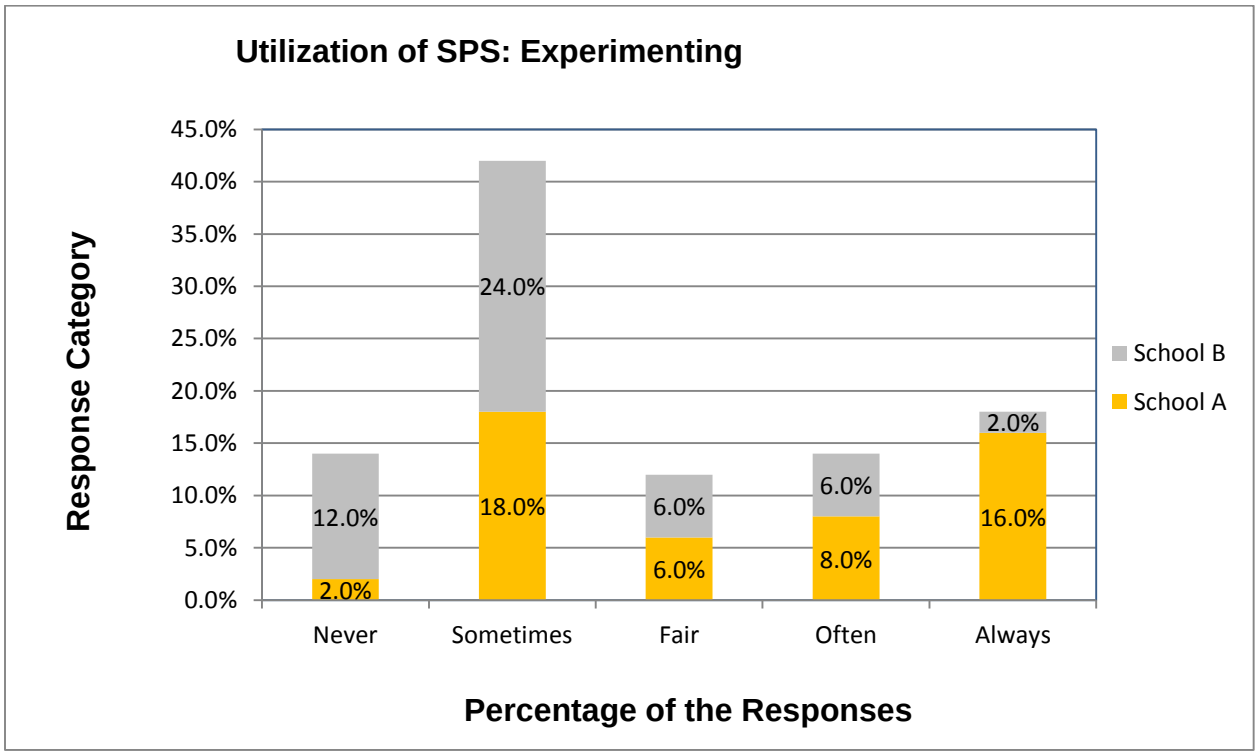


Figure 4.3: Usage of Integrated (Experimenting)

The results displayed on the graph above are for experimenting as an integrated science process skill. These results were obtained from item 20 on the learner questionnaire. Fifty Grade 11 Physical Science learners ranked how they utilized experimenting on a scale of 1 to 5 (e.g. with 1= Rarely, 2 = Sometimes, 3 = Fair, 4 = Often and 5 = Always). The outcome on the graph above revealed that most learners 42% (School A = 24%, School B = 18%) sometimes utilized experimenting followed by those who always (18%) utilized and those who rarely (14%) or often (14%) utilized experimenting SPS. These results followed the trend noticed by previous researches conducted in the field of science process skills which noted that experimenting

experience a sometimes to fair utilization by Physical Science learners (Ercan, 2007, Miles, 2010; Jumanne, 2012).

Utilization of Integrated SPS of conducting investigations, relationships between variables, design hypothesis was as follows: The outcomes of ratings on the relationship between variables SPS showed a highest utilization rating on the "fair" utilization category with a score of 40% (School A = 12%, and School B = 30%), followed by no utilization rating of 22 % (School A = 4% and School B = 18%). Thus, there is a low utilization of the SPS of relationship between variables. Researchers (for instance, Ercan, 2007; Miles, 2010) have noted that through knowing the relationship between variables, learners are able to determine effects of variables on some certain trends. Rambuda and Fraser (2004) in their study about trends of science process skills discovered that there is a low skill transfer of integrated science process skills from science teachers to science learners for learners who originate from low to middle income households. This implies that scientific resources are vital for utilization of science process skills (Ercan, 2007).

In terms of utilization of designing investigations, the highest rating of 36% (School A = 8% and School B = 28%) was received at the no utilization rating category closely followed by the sometimes utilization category of 32% (School A = 14% and School B = 18%). This shows that designing investigations is one of the least utilized science process skills. According to the American Association for the Advancement of Science (AAAS, 2010) designing investigations is not the same as conducting investigations. When designing investigations science learners have to plan, think and invent the methods and apparatus needed to test a new or existing hypothesis. However, when conducting investigations science learners will just follow a set of laid down procedures to determine variable outcomes (AAAS, 2010). Studies (e.g. Ercan, 2007; Miles, 2010) have noted that through investigations and data collection, science learners can carry out scientific procedures and a set of instructions that enables conclusion to be reached. Science learners may follow stated rules on a worksheet, for instance, to set up laboratory apparatus or conduct an investigation and thereafter, record the data. In some cases, designing an investigation can be a demanding task where science learners has to use other process skills like observations, collecting data, calculations, analyzing data and drawing conclusions in-order to solve a stated problem (Bybee and Deboer 2001; Rambuda and Fraser, 2004). Regarding the

position of the extant literature, most investigations (see Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011) showed a comparable position shown by the results of this study which noted that for most integrated science process skills learners do score a low level of utilization.

Effects on science process skills on understanding of new science topics and passing examinations: The present study notes that science process skills have a significance impact on learner understanding of new science topics and passing examination tasks. The utilization of science process skills scores for both basic and integrated science process skills was in favor of learner ability to understand new science topics and passing examination tasks. The highest number of learners (92%) concurred that science process skills assist them to understand new science process skills. Similarly, most learners (93%) also agreed that utilization of science process skills assist them to pass examinations. Besides, there was a high correlation coefficient (0.742) between a high utilization of science process skills and learner ability to understand new science topics. This was show by the correlation table below which was generated using SPSS version 22 software. Ercan (2007) and Miles (2010) report a relationship between science process skills and passing examinations or understanding new topics when they say that learners who displayed high utilization of science process skills passed a competency science evaluation test than those who poorly utilized SPS. Furthermore, further studies maybe instituted to find out how science process skills affects conceptualization of difficult science content areas.

Table 4.4: Spearman's correlation coefficient between learner ability to understand new science topics and utilization of science process skills

			Q23EffectofSPSNewConcepts	Q25FrequencyUSe
Spearman's rho	Q23EffectofSPSNewConcepts	Correlation Coefficient	1.000	0.810
		Sig. (2-tailed)	0.000	0.742
		N	50	50
	Q25FrequencyUSe	Correlation Coefficient	0.810	1.000
		Sig. (2-tailed)	0.742	0.000
		N	50	50

Ercan (2007)'s study on the effects of science process skills on learner's aptitude in science topics also revealed that there is a high linkage between utilization of science process skills and learner aptitude ability. Thus, a further study may be instituted to track on the impact of science process skills on learner conceptualization of new scientific topics.

4.4 Interview results on the extent of utilization science process skills

As indicated earlier concerning the sequence of presenting results, firstly learner questionnaire results followed by teacher and learner interview findings and lastly interview schedule results. As reported above, the major finding of learner interview results was that the extent of the utilization of utilization of each science process skills varied from one science process skill to the other. The learner questionnaire data also showed that there is higher utilization for basic than integrated SPS and that School A from high income earning households had a higher utilization of both basic and integrated SPS than learners from School B. Analysis of the questionnaire was mostly done by evaluating the rating undertaken on the extent of the utilization of science process skills questionnaire items. Fifty Grade 11 Physical Science learners ranked how they utilized experimenting on a scale of 1 to 5 (e.g. with 1= Rarely, 2 = Sometimes, 3 = Fair, 4 = Often and 5 = Always). These results were tabulated using SPSS and analyzed further as presented above.

The results below are from teacher and learner interview schedules. Teacher interview results are presented first followed by learner interview results. As indicated in Chapter three, two teachers each school participated in the interviews. These interview responses were further coded and placed into key themes and underlying factors indicating utilization of science process skills were identified. Key words indicating extent of utilization and similar codes from all interview participants were grouped. Verbatim sentences were checked word by word to find major indicators as to how utilization of science process skills unfolded in Grade 11 Physical Sciences for both schools.

4.4.1Teacher interview results

Learner questionnaire results showed that the extent of the utilization of utilization of each science process skills varied from one science process skill to the other, and that learners' lack utilization of integrated science process skills compared to basic science process skills. Teacher interviews corroborated these findings. Thus, both data sources concurred in most aspects of the findings. A similar finding was that learners from low income utilize SPS more unfavourably compared to learners from high income communities. This confirms what was found by other studies (for example, Ferreira, 2004; Ercan, 2007 and Miles, 2010). For instance, Miles (2010) found that designing investigations as an integrated SPS received the lowest mark in a SPS test compared to most basic SPS. All the four interviewed teachers concurred that Grade 11 Physical Science learners lack key aspects of integrated science process skills in terms of utilization, application and implementation during their science engagements. Harlen (1999) argues that the acquisition of integrated science process skills is integral in the learning of science to enable learners to comprehend the world and make necessary connections with scientific phenomenon. Thus, in short teacher's interviews confirmed results from learner questionnaire which highlighted that there is a poor utilization of integrated science process skills?

As was also reported by learner questionnaire results, the most used science process skills according to teacher interviews is communication, observing and classification. The least used science process skills, as reported by teacher interviews, is relationship between variables, controlling variables and predicting. Ferreira (2004) and Ercan (2007) also found similar results. They discovered that the easily used and most frequency utilized SPS by both primary and high school learners are communication, observing and classification. The following extracts are illustrative:

Teacher X Interview: Teacher X was a pseudo name given to a teacher in School B. As reported in the methodology chapter, this teacher had more than 18 years' experience. When this teacher was interrogated about utilization of his learners' science process skills, he stated that:

> My learners are able to frequently classify scientific phenomenon, and always engage in science communication and also often do observations during lessons or practical tasks,

> however when it comes to predicting, hypothesis or design investigations, there is still some huge challenges they are poor in these kinds of science process skills.

Teacher Z Interview: Teacher Z was a pseudo name for a teacher from School A. This teacher had 4 years' experience as stated in Chapter 3. About utilization of science process skills, this teacher pointed out that:

> Learners are very clever in and always utilize communication, describing, identification and comparing but do not often utilize constructing graphs, designing hypothesis and controlling variables. Hopefully I will assist them more.

The above extracts point to a higher utilization of some science process skills than others. This shows that there is variation in utilization of science process skills from one science process skills to the other. This confirms learner questionnaire results. This is in line with the findings of Ferreira (2004) and Ercan (2007) who observed a comparable trend and noted that utilization of science process skills is highly depended on the type and specifics of each SPS. This however contradicts Miles (2010) who says utilization of all science process skills is the same. It can be argued that all in all this result confirms that utilization varies from one science process skill to the other, with a greater utilization being biased towards basic science process skills than integrated science process skills. Miles (2010) contents that teachers should be in the forefront of developing their learners' science process skills to ensure that learners can effectively utilize these skills in subject matter assimilation, examination reasoning skills and questioning abilities. The current results suggest that there is a need for additional research to find out the ways teachers can develop their learners' science process skills.

Some studies (for example, Downing and Gifford, 1996; Ercan, 2007) show that science teachers with higher qualities in SPS are more active and have greater emphasis in teaching these abilities to their learners. A study by Rambuda and Fraser (2004) discovered that teachers themselves lack some attributes of integrated science process skills and struggle to teach these skills. In the present study teachers pointed-out that they possess some level of inadequate skills in terms of developing their learners' science process skills. This was revealed during teacher interviews. It looks like the less experienced teachers are the ones who revealed that they struggled to train their science learners' skills of controlling variables, designing experiments

and making some reasonable inferences with scientific phenomenon. However, a study by Miles (2010) shows that even though teachers could have mastered science process skills during their college training years, they could easily neglect implementation of these skills in the classroom. Therefore, there is a need for both pre-service and in-service teachers to be trained in conceptual understanding and conceptual application of science process skills, so that they can efficiently cascade them to their learners (Ercan, 2007).

4.4.2 Learner interview results

Analysis of learner interviews showed that Grade 11 Physical Science learners have a higher utilization of skills like observation, communication, calculation and classification than other SPS. As was also detailed by teacher questionnaire results, analysis of learner interviews indicated a poor utilization of science process skills like predicting, controlling variables and experimenting.

A closer look at one of the highly used science process skills for the present study, for instance, observation shows that it is one of the most fundamental of all processes skills (AAAS, 2010). Physical Science observations can be explained as the ability to gather information using one or more of the basic human senses; hearing, taste, smell, touch and sight. Observation teaching should include objectivity and more specific details of the phenomenon under observation (Ercan, 2007). In the scientific field, tools like technology, microscopes and instruments are making observations easier. Observations enable Physical Science learners to analyze and review scientific issues and thus inform their decisions and conclusions.

One of the lowly utilized skills for this current study, prediction reveals that its low utilization should raise alarm (Ercan, 2007). Prediction entails projecting activities based upon given facts and knowledge. The American Association of Advancement of Science (AAAS, 2012) report states that one might project in a future tense, a sort of trend analysis, or one might look for an historical precedent to a current circumstance. In either prediction emerges from a data base rather than being just a guess. A guess is not a prediction. This implies that predictions should be tested and consequently accepted or rejected based on a standard evaluation criteria. Thus, the attribute of predicting is the ability to identify a trend in a large body of data and then

being able to forecast in a way that can be tested (Ercan, 2007). The following are some excerpts from learner interviews:

> *Learner 1 from School B:* The process skills that I am able to use and work with are using numbers, observing and measuring. Using numbers is where we calculate certain percentages or number of certain particles in one given topic. Observing is listening and seeing what you are doing in an experiment. Measuring is to measure the maximum number of something. But things like controlling variables I do not regularly use them
>
> *Learner 2 from School B:* I regularly use with communicating, comparing, predicting and observing. I am able to use learnt information and explain it in the manner that I have understood it. I am able to make comparisons of objects in the experiment I am doing. I can observe something by merely looking at it. But I find it difficult predict or design investigations
>
> *Learner A from School A:* They do help me to an average extent because some topics are difficult to understand. Even though at times I try to apply them they are still usually average
>
> *Learner B from School A*: Communication actually helps me to pass my science as it helps me to understand the subject as well as knowing and not cramming. It also makes science interesting to learn. It helps me to calculate, interpret data, observe and learn more about science. Somehow I can predict weather but other issues like designing hypothesis I rarely use them

As was also found from the learner questionnaire results, these learner interview excerpts suggest that there is relatively high utilization of basic science process skills (communication, observation, calculations and classification). They also show that integrated science process skills had low utilization, for instance Learners 1 and 2 from School B stated that they did not regularly utilize prediction process skill, for instance.

An interesting finding from learner interviews is the variation of utilization of science process skills in terms of gender. The interview analysis shows that there is a relatively small significance difference in the utilization of science process skills for both girls and boys. However, utilization is slightly biased towards boys. A similar result was also found by Ercan

(2007) who discovered that gender variations do not feature in the utilization of science process skills. However, Yilmaz and Meral-Kendemir (2012) found that boys tended to have higher utilization than girls. The reason for gender disparity could be because of cultural factors such as upbringing of male and female learners. For instance, in South Africa, the Zulu culture has certain roles associated with males and roles associated with females (Fullan, 2007). This gender bias in terms of learner utilization of science process skills is alarming.

4.4.3 The place Physical Science learners' utilization of science process skills

Item 1 on the learner questionnaire sought to gather information concerning the place where the Grade 11 Physical Science learners usually use science process skills. Rambuda and Fraser (2004) not that the place of using SPS provides an insight on the frequency of utilizing SPS, since some places discourage utilization (e.g. learner play stations) whilst other promotes utilization (e.g. schools, colleges, science industries). However, almost all of the surveyed learners (94%) indicated that they utilize SPS mostly at school, whilst only a small proportion (6%) indicated that they utilized SPS mainly at home. This shows that indeed schools are and should continue to play a pivotal role in developing science process skills of learners. These skills form a backbone for science careers (Ercan, 2007). Concerning schools being in the forefront of advocating utilization of SPS, the Department of Basic Education guidelines (DoBE, 2011, p. 122) states that:

"Schools as provided by the National Curriculum Statement Grades R-12 should aims to be leaders in producing Physical Science learners that are able to:

- identify and solve problems and make decisions using critical and creative thinking;
- work effectively as individuals and with others as members of a team;
- organise and manage themselves and their activities responsibly and effectively;
- collect, analyse, organise and critically evaluate information"

4.4.4 The appropriate school phase or level learners begin to utilize SPS

Item number 2 on the questionnaire generated information as to when learners start using SPS. The beginning phase or age when a child should start to apply and use SPS was said to be

vital by science education researchers (e.g. Robertors and Sunders, 1998; Bybee and Deboer 2001; Rambuda and Fraser, 2004). The results showed that most learners (52%) started utilizing science process skills at primary level, followed by 46% at who pointed out that they started to utilize SPS at secondary level. Only a very small fraction (2%) of the sample indicated that they started to utilize SPS at home. Researchers (i.e. Bybee and Deboer 2001) have recommended that science learners should start to utilize SPS at primary level so that they achieve an early mastery of these skills at tender ages. Early age of SPS utilization also enables skill refinement and interest creation during a child's elementary stages. Learners who delayed utilization of science process skills will have difficulties in coping with science activities during later stages (Bybee and Deboer 2001). Thus, having 46% percent of the learners starting to use SPS at secondary level provides some insight why some learners may be have an irregular utilization of these skills at Grade 11 level.

4.5 Analysis of factors hampering the utilization of SPS

The figure below indicates the results from learner questionnaire rating on the factors that hamper their ability to utilize science process skills. Item number 26 asked the fifty Grade 11 Physical Science learners to indicate which factors affected how they utilization science process skills.

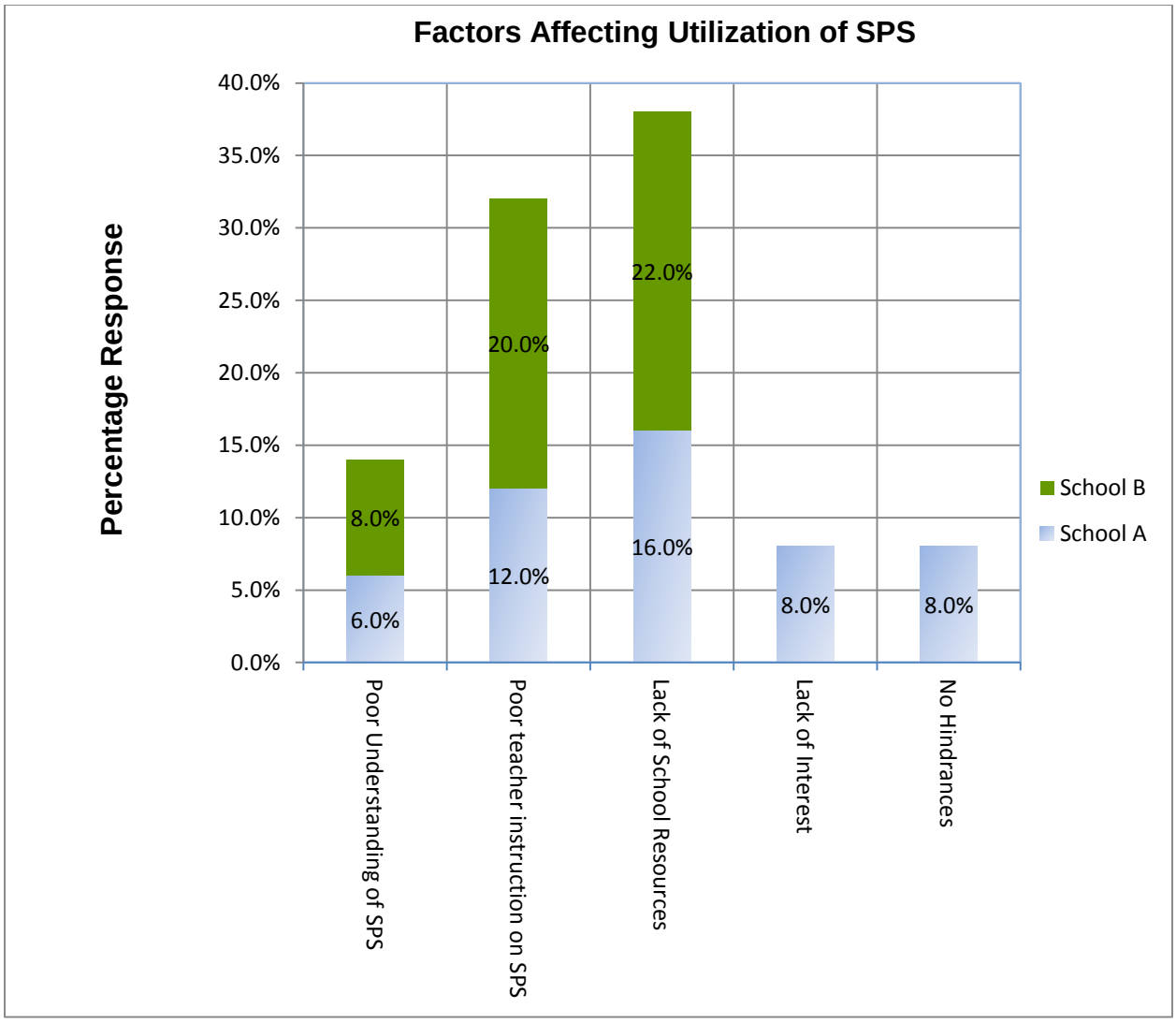


Figure 4.4: Factors Affecting Usage of SPS

The results revealed that both Schools experienced lack of resources (38%) and teacher competence (32%) as the most factors hampering utilization of science process skills. School A had about 8% who lack of interest in terms of utilizing SPS. A comparable study by Miles (2010) highlighted that teachers should put good measures like provision of incentives to generate their learner's interest in science-related activities. Bucat (2005) outlined that Governments should be on the forefront of equipping schools with resources to ensure experiments, calculations, design of investigations are utilized at schools. In terms of teacher ability and curriculum issues, the modern South Africa is currently rolling-out CAPS – Curriculum and Assessment Policy Statement in all its educational systems. This new curriculum has adopted elements of the

scientific methods including guidelines on utilization of science process skills from primary school level. The guidelines for the Department of Basic Education (DoBE, 2011) noted that a National Curriculum and Assessment Policy Statement (CAPS) is a "single, comprehensive, and concise policy document, which is replacing the current Subject and Learning Area Statements, Learning Programme Guidelines and Subject Assessment Guidelines for all the subjects listed in the National Curriculum Statement Grades R - 12". In summary, CAPS is a revision of the current National Curriculum Statement (NCS).

Further, with the introduction of CAPS, Physical Science in each grade has a single, comprehensive and concise policy document that provides details on what teachers need to teach and assess on a grade by grade basis. This policy document details key procedures on utilizing science process skills. This curriculum review has the aim of lessening the administrative load on teachers, and ensuring that there is a clear guidance and consistency for teacher instructions on developing their learners' scientific skills. Therefore, the major changes in CAPS Physical Sciences practices are that of a detailed guidance and teacher direction on utilizing science process skills. Such huge changes in the curriculum create a good environment for efficient and effective learning of science process skills (Ongowo and Indoshi, 2013). This implies that teachers are no longer expected to be incompetent in assisting their learners to utilize science process skills.

4.5.1 Interview on factors hampering utilization of SPS: Teacher Y

In-order to probe the underlying which factors associated with low utilization of science process skills, 2 teachers from both schools asked a range of questions (see appendix C on teacher interview schedule). The in-depth questions sought to solicit facts about issues that hamper utilization of science process skills. The interview results were then coded and key themes were identified. Using a content analysis approach, interview responses are double-checked word by word to note underlying themes.

Teacher Y showed considerable interest in participating in the interview. He was from School B, a non-fee paying school. He had a vast experience of 18 years teaching science. His

qualifications were a diploma in science education, as was noted in the methodology. In terms of poor utilization of science process skill, this teacher stated that:

> Usage of science process skills at this school is blocked by many issues such the skewed curriculum of our nation, learner behaviour and lack of interest in education. Our learners do not like school

Further prompts and probes revealed that this teacher blamed curriculum policy planners in South Africa. He stated that they do not include a variety of science activities that encourage the practice and engagement of Physical Science learners. He went further to point to learner participation and learner behaviour as one of the cause of poor performance at his school. He stated that learners manifest negative behaviours such as:

- Some learners have no interest in participating in science activities that can build their process skill;
- Some learners temper with laboratory equipment during science activities;
- Some learners do not care about science activities or even learning itself;
- Some learners engage in wrong discussions during science activities

4.5.2 Interview on Factors hampering utilization of SPS: Teacher Z from School A

This teacher was new in the field of teaching science. She had 4 years of experience and her qualification was a Bachelor of Education in Science. The teacher was interrogated about possible issue that hampers utilization of science process skills. She pointed out that lack of resources at the school has a greater bearing on utilization of science process skills. She noted that even though the school was a modest top performing school, nonetheless resources like full experimental kits for various scientific topics and science activities were not present. She revealed that the school had a well-built laboratory; however, key Physical Science materials to assist in utilization of SPS were not present. For instance, thermometers and some chemicals for use in designing investigations were not available. She also alluded that this was due to lack of procurement of science materials by the school authorities who usually priorities other materials such as books. She wanted the school to procure all materials that will make science activities enjoyable to all learners and which also make utilization of science process skills easier.

The other issue she raised was that she was not yet competence to demonstrate all science process skills to her learners because she was still new in the system of teaching science. She said she had hoped to be trained in science refresher courses on utilizing scientific materials during teacher workshops at the District Education Cluster meetings. However, her hope was dashed out when she noted that the district cluster meetings were mostly discussions on how to make learners pass examinations with high marks. She queried:

> How can the authorities talk of making learners pass all the times, yet they do not equipped on how to use different teaching methods or using science process skills in our science activities

Teacher educational in-house training programs should provide a vital support to equip young teachers with science process skills (Rambuda and Fraser, 2004). Activities such as laboratory work, simple investigations, teacher educational programs and resource provision should be practices that provide additional fundamental skills for teacher utilization of science process skills. Consequently, there is a need for further studies on finding out how the ways of teacher utilization of science process skills inform and determine learner utilization of science process skills.

Whilst findings on learner questionnaire concerning factors associated with poor utilization of science process skills pointed to shortage of scientific resources and teacher competency, however, teacher interview results from School B blamed curriculum issues and learner attitudes as factors pointing to low utilization of SPS. This was noted mostly for integrated SPS. Nonetheless, all the identified factors from both data sources were highlighted by previous comparable studies (see for example, Mohammed, 1983; Ferreira, 2004; Mutlu and Temiz, 2013) about issues that hinder utilization of science process skills. The sampled science teachers provided a more narrative picture of factors hampering utilization of SPS which had not been highlighted especially at Grade 11 level for physical science by previous studies.

4. 6 Analysis of lesson observations

As indicated earlier, the last sequence of presentation on the findings for this study is results from lesson observation. The present study generated information as to the extent of

utilization of science process skills using an observation schedule. Chapter three on methodology outlined how the interview schedule used for this study was adopted and modified from a previous similar study (Bulent et al, 2014). For both schools one lesson was observed. Physical Science learners were given a science task which favoured concurrent utilization of several science process skills. Because of school time constraints, the lesson observation was just a single lesson of 40 minutes for each of the two schools. However, the researcher made some arrangements to ensure that he can generate and analysis meaningful data from the observation. At both schools, few learners (e.g.3 learners) participated in the lesson observation. The three learners from each school were given a science task (e.g. determining the effects of heat on time) and science materials that stimulated utilization of science process skills. The reason the number of learners was reduced was to allow the researcher to clearly obverse learner activities that is learner by learner. The science tasks and materials that were given to the science learners encouraged utilization of both basic and integrated science process skills. The first 10 minutes of the lesson was for explaining the science task that was given. With the help of their science teacher leading activities, the researcher went around spending 10 minutes per each group and observing the kinds of science process skills that were mostly being utilized. This was recorded on an observation schedule (See Appendix D). A table below shows the analyses of the observation of three basic science process skills and two integrated science process skills.

Table 4.5: Findings of Lesson Observation

Name of SPS	**Learner**	**School A**			**School B**		
		Poor Performance	**Fair**	**Good Performance**	**Poor Performance**	**Fair**	**Good Performance**
Classification	Learner 1			X		x	
	Learner 2			X			X
Communication	Learner 1			X			X
	Learner 2			X			X
Observation	Learner 1						
	Learner 2						
Prediction	Learner 1		X			x	
	Learner 2	X				X	
Controlling Variables	Learner 1		X				
	Learner 2	X					

The findings from the lesson observations confirmed findings from other data sources for this study (e.g. learner questionnaire and interview schedules), for example, learners' ability to utilize science process skills varies from one science process skill to the other. As noted by other sources of data for this study, basic skills had a higher utilization that integrated science process skills. An additional trend noted during lesson observation was that learners lack hand-on-skills to do practical laboratory work. They seemed not to be sure of the function or use of a number of laboratory apparatus they were given. This is another factor that hinders utilization of science process skills. Ercan (2007) detailed that when learners are not familiar with science apparatus and science material, then they will display poor utilization of science process skills. With the exception of school contextual differences, these trends emanating from this study confirms other comparable investigations ((see Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011) on science process skills. For instance, this study noted that learners lag behind in terms of practical skills that generate abilities for using most science process skills. This position was also highlighted by Ercan (2007) and Miles (2010).

4.7 Pertinent comments on the science process skills in South Africa

In summary, the findings revealed that on overall learners are relatively proficiency in basic science process skills especially communication, observing, measuring and quantifying. Thus, the utilization scores of basic science process skills is more higher than integrated science process skills. The eigenvalue factor for the significance of learner utilization of basic science process skills was 0.969 as shown by the table below which was a relatively good value reflecting good participation of learners in basic science process skills. Eigenvalues were generated using SPSS statistical software Version 22 using learner questionnaire data generated from learner questionnaires. Eigenvalues are used in factors analyses to show which factors are significant (Miles, 2010).

Table 4.6 Eigen values of learner utilization of basic science process skills

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	0.969[a]	100.0	100.0	0.719
Canonical discriminant functions were used in the analysis.				

However, for integrated science process skills there is a poor utilization as was reflected by a high standard deviation (e.g. 1.35 of mean scores). The standard deviation was generated by the SPSS Version 22 from learner questionnaire data. A higher standard deviation reflects bigger gaps between mean scores. Therefore, as reported by other studies (e.g. Bybee and Deboer 2001; Rambuda and Fraser, 2004) learners in South Africa are less proficiency in integrated science process skills.

The vision of CAPS (DoBE, 2011) in South Africa is to give a greater need for cognitive skills such as communicating, observing, classifying, predicting and formulating hypothesis. Therefore, there is a huge learner skills gap in terms of integrating the skills. Thus, Roberto (2011) outlined that to master integrated science process skills learners should thorough learn inquiry processes and constructing meaning as well as engaging in demanding science tasks. This creates skills for utilizing integrated science process skills.

A study by the National Research Foundation (NRF, 2007) recommended the promotion of both basic and integrated science process skills as pillars of building science skills in children at both primary and secondary level. To this end, Leonard and Penick (2009: p. 259) outlined that "standard-based activities should engage the students in observing; asking and identifying questions and problems; identifying dependent and independent variables; formulating hypotheses; designing and conducting experiments; manipulating independent variables;

collecting data; organizing data; displaying data; inferring from data; generalizing; applying generalizations; communicating results; and formulating new hypotheses.*"*

The American Association for the Advancement of Science (AAAS, 2010, p101) pointed out that "science should be taught as it is practiced". However, in South Africa this somehow remains a pipe dream as teachers themselves are not highly proficiency in science process skills (Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010). The AAAS (2010) suggested a range of measures to ensure usage of both integrated science process such as:

- During science lessons, keep the science activity groups as small as possible (e.g.5 learners in group)
- Teachers should specify tasks that present more usage of integrated science process skills
- Greater monitoring of learners engaged in science activities
- Giving learners graded science activities to encourage participation
- Making science tasks more challenging

4.8 Conclusion

Overall, the results of this study show that the extent of utilization of science process skills varied from one science process skill to the other. In-order to present a detailed analysis regarding utilization of science process skills by Grade 11 Physical Science learners, the results was analyzed in two categories, which are; basic and integrated science process skills. The results were also analyzed, presented and discussed in terms of science process skill utilization by school type, that is, School A = fee paying school, and School B = a non-fee paying school. Generally, these results show that basic science process skills are relatively more frequently utilized compared to integrated skills. The most utilized basic science process skills are; communication, observation, identification, classification, comparison, description and calculation. The results reveal that the following integrated process skills are poorly utilized by the Grade 11 learners- prediction, constructing hypothesis, relationship between variables, constructing diagrams, and experimentation.

When comparing the two schools it was found that School B had a lower utilization of both basic and integrated science process skill when than School A. As earlier mentioned, School

A comprises of learners who are mostly from relatively high income earning families. School A was classified a modest school, with high annual Matric pass rate. School B is a township one made-up mostly of learners from low to middle earning households and normally produces average or poor Matric results. All in all, the study results suggest that science process skills assist Physical Science learners in understanding new science concepts and consequently contribute to high marks in examinations.

The above conclusions were reached as a result of analysis of three data sources, that is, learner questionnaire, teacher interviews and learner interviews and lesson obervations. Generally, when both school types are considered, to a large extent there is a high utilization of science process skills like observation and communication and low utilization of science process skills like designing investigations and predicting. Factors most associated with hampering utilization of science process skills were identified as: teacher competency; learner interest; curriculum issues; and poor teaching practices; and poor learning strategies. In Chapter five, the general conclusions and implications coming out of this study are presented. Recommendations for further studies, teaching, learning and curriculum reform are suggested.

CHAPTER 5

Conclusions, Implications and Recommendations

5. Introduction

The purpose of this study was to investigate the use of science process skills by Grade 11 Physical Science learners. This study particularly focused on the extent of utilization of science process skills, the factors associated with utilization of science process skills and how science process skills influence passing of examination tasks. From the results and discussion outlined in Chapter 4, the four main conclusions from this study:

1. The extent of utilization of science process skills differ from one science process skill to the other. There is a greater utilization of basic science process skills among Physical Science learners and the order of utilization of basic science process skills from high to low: communication, observation, identification, classification, describing, calculations and drawing diagrams. There is a poor utilization of integrated science process skills among Physical Science learners and the order of utilization of integrated science process skills from poorest to fairest: designing investigation, constructing hypothesis, prediction, experimenting and relationship between variables

2. The School which had science learners from high income earning families experienced a high utilization of science process skills than school with learners from low income earning suburbs.

3. Science process skills have an impact on learner performance in examination tasks and understanding new science topics.

4. The factors associated with poor utilization of science process skills among Physical Science learners were noted to be mostly shortage of resources, teacher competency and learner attitude.

These conclusions are teased-out separately in the next sections.

5.1 The extent of utilization of science process skills

Results from all the three data sources for this study, that is from learner questionnaire, teacher and learner interviews and lesson observation schedules disclosed that utilization of science process skills differ from one science process skill to the other. During this study 50 Grade 11 Physical Science learners participated in the study and data that was generated which revealed that the utilization of basic science process skills was mostly favourable and the utilization variation of basic skills from high to low was as follows: communication, observation, identification, classification, describing, calculations and drawing diagrams. The learner questionnaire findings also showed that for integrated science process skills, the order of utilization of integrated science process skills was mostly undesirable and the utilization disparity of integrated skills from poorest to fairest was as follows: designing investigation, constructing hypothesis, prediction, experimenting and relationship between variables. This trend was also observed by Miles (2010) who noticed that basic SPS are inherent in learners whilst integrated SPS need to be cultivated in learners. Furthermore, other studies confirm this stance of low usage of integrated SPS and high usage of basic SPS (see Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011).

Concerning the statistical analysis carried out on this study, the descriptive indicators from questionnaire data shows that Grade 11 Physical Science learners attained a utilization percentage score level (UPSL) for basic science process skills of 68%. Integrated science process skills showed an overall utilization level of 42%.

5.2 How utilization of basic science process skills differed from the two schools

The analysis and discussion of the findings collected using learner questionnaire, teacher and learner interviews and lesson observation schedule showed that the utilization of science process skills was relatively high for learners from the school located in high income earning households than for the school with learners from low income earning suburbs. This trend was noticed for both basic and integrated science process skills. For instance, the descriptive statistics from questionnaire data shows that Grade 11 Physical Science learners attained a utilization percentage score level (UPSL) for basic science process skills of 71.88% for School A and

64.72% for School B. Integrated science process skills showed a utilization level of 46.23% for School A, and 42.16% for School B. This finding is consistency with comparable studies (Burke, 1996; Pekmez, 2001, Rambuda and Fraser, 2004; Miles, 2010). The results in Chapter 4 disclosed that the mean scores for most integrated science process skill is higher for School A (i.e. Overall integrated science process skills mean score, OISPS-MS = 2.38) than for School B (i.e. Overall integrated science process skills mean score, OISPS-MS = 2.12). The mean scores were generated from the learner questionnaire data using SPSS Version 22 statistical software.

In addition, a t-test was conducted to evaluate the significance for utilizing science process skills between School A and School B using combined average ratings for the two schools. The Statistical software SPSS Version 22 was used to generate results for the t-test. The t-test was based on the comparison of the utilization percentage scores for School A and School B. According to the t-test ($F = 3.11$, $p \leq 0.05$), the differences of utilization between basic and integrated science process skills was more significantly biased towards basic skills (i.e. F significance level = 3.11, favouring basic science process skills). This similar analytical approach was also used by other studies on SPS (Chan, 2002; Ercan, 2007; Nakiboglu, 2011).

Miles (2010) noted that science process skills are vital competencies that every child should acquire and utilize effectively. His studies revealed that learners from low income families are normally hindered by lack of resources in their quest to utilize science process skills.

5.3 Factors hampering utilization of science process skills.

The findings generated using learner questionnaire, teacher and learner interviews and lesson observation schedule showed the factors associated with low utilization of science process skills in the order from high hampering to low hampering was shortage of resources, teacher competency, skewed curriculum polices, learner attitude and lack of support by learner parents. In addition, teacher interviews revealed a particular undesirable trend stemming from learners' behavioural trait which was reported to hamper utilization of science process skills. This was noticed specifically for learners from the school located in a low income suburb. Teacher interviews testified that this trend which disclosed that learners manifest negative behaviours such as:

- Some learners have no interest in participating in science activities that can build their process skill;
- Some learners temper with laboratory equipment during science activities;
- Some learners do not care about science activities or even learning itself;
- Some learners engage in wrong discussions during science activities

This finding is in line with a learners' negative characteristic detailed by Burke (1999) who noted that learners from crime ridden and low income families lack a huge interest in school science.

5.4 Implications and recommendations for science teaching

The results for this study suggest that the teaching and utilization of science process skills is inconsistent with the recommended standard by science curriculum reform. For instance, the major aim of science teaching according to the Department of Basic Education is that science learners should:

> "The National Curriculum Statement Grades R-12 aims to produce Physical Science learners that are able to:
>
> - identify and solve problems and make decisions using critical and creative thinking;
> - work effectively as individuals and with others as members of a team;
> - organize and manage themselves and their activities responsibly and effectively;
> - collect, analyze, organize and critically evaluate information;
> - communicate effectively using visual, symbolic and/or language skills in various modes;
> - use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
> - demonstrate an understanding of the world as a set of related systems by recognizing that problem solving contexts do not exist in isolation", (DoBE, 2011, p 8)

This means that science education should be evaluated to find out if science teachers and all relevant stakeholders are aware of the intended professional standards for science process skills. Most learners do not display an excellent utilization of integrated science process skills. This will

have an impact in their ability to understand new scientific topics or perform excellently in science examination tasks (Miles, 2010). Furthermore, learners tend to be withdrawn during science activities because of the lack of relevant skills to participate in science deeds (Ercan, 2007).

Professional utilization of science process skills should be an aim of all learners and all schools (Chan, 2002; Ercan, 2007; Nakiboglu, 2011). Nakiboglu (2013) argued that the major achievement on SPS should be to let science learners become highly competent in the basic skills and then they can cope with integrated science process skills as they go along. However, for high school science learners, proficient in both types of skills should be profoundly emphasized (Miles, 2010).

5.5 Recommendations for policy makers and curriculum developers

The results of this study mean that the South African curriculum needs to be reviewed in terms of policies that advocated for profound emphasise on utilizing science process skills. The study has disclosed that there is a low utilization of integrated science process skills. The study also showed that science process skills have a bearing on how learners master new science topics and how they perform in examination tasks. This suggests that the curriculum should be redesigned in such a way that it captures practical steps which science teachers need to carry-out to ensure that learners utilize science process skills. It is recommended that professional development strategies that focus on utilization measures such as ways of designing investigations, time slots of teachers taking learners through scientific prediction tasks, making hypothesis and designing investigations. A roster for each school term can be created so as to gauge utilization of science process skills by learners as supervised by science teachers (Ercan, 2007; Miles, 2010). Measures to eliminate factors hampering utilization of science process skills should be instituted, these can mean budget allocated for inquiry deeds, refresher training workshop focusing on SPS and motivation of learners with regard to the importance of science process skills. Furthermore, it is advised that curriculum designers should include annual science product exhibitions, where science learners participate and get rewarded for a science product developed which reflect high usage of most integrated science process skills (Burke, 1999; Nakiboglu, 2013).

5.6 Recommendation for further research

Previous studies have focused on teacher and learner utilization of science process skills according to many variables (see Chan, 2002; Rambuda and Fraser, 2004; Ercan, 2007; Miles, 2010; Nakiboglu, 2011). The current study found out that utilization of science process skills varied from one science process skill to the other. This study also disclosed that basic science process skills experience a high usage compared to integrated science process skills. It was also noticed that learners from low income households incur a relative low utilization of science process skills than those from high income families. The findings showed that factors associated with low utilization of science process skills are mostly resource shortage, teacher competency and learner attitude. Recent studies (see for example, Nakiboglu, 2013) focused on how gender affected utilization of science process skills. Studies (Chan, 2002; Ercan, 2007) have also been conducted regarding usage of science process skills in comparison to science teachers' education level and experiences. Investigations concerning how science process skills affect laboratory practical work has been conducted (Jepp, 2014). However, there seems to be a gap that was noticed during the course of this study. Therefore, it is recommended that further studies be instituted in terms of how science process skills affects conceptualization of new science facts. In addition, further research should be done to explore the ways which improve utilization of science process skills.

5.7 Strengths and limitations of the study

In most educational research undertaking there are some strengths as well as limiting factors. These factors might affect the credibility of the study either positively or negatively. One of the strengths of this study is the use of triangulation of sources of data which helped the researcher to establish utilization a reliable extent to which science process skills were being utilized. Secondly, the recording technique of the interviews reduced bias as true intentions of the respondents was captured. Thirdly, the researcher had worked with SPSS statistical software and was well prepared in terms statistical analysis.

The sample that was employed for this study was too small to be considered representative for South African science learners and teachers. For this reason, the conclusions

reached in this study are mostly generalizable to the sampled schools and teachers. Nonetheless, these conclusions will be relevant to all other schools and teachers in South Africa.

The researcher was a beginner in conducting interviews. This could have affected the collected data in some ways. Interview techniques such as probing and soliciting might not have been fully exploited. However, the findings from the interviews were corroborated by results from the learner questionnaire.

The validity of observational data is affected mainly by the observer than on those being observed (Borg and Gall, 1983). Therefore, some bias in observation could have been incurred. However, observation findings were equivalent to data from interviews and learner questionnaire.

5.8 Conclusion

In this chapter, the following conclusions were made based on the findings from this study. Utilization of science process skills varied from one process skill to the other. Basic science process skills incur high utilization than integrated science process skills. Learners from high income families displayed a relatively high utilization of SPS than those from low income earning areas. Shortage of resources, teacher competency and learner attitude are the foremost factors hampering utilization of science process skills. Recommendations made for this study includes annual science product fairs to raise motivation for using science process skills. It was also advised that relevant policy departments redesign policies to include measures that monitor science classroom utilization of science process skills. Strengths and weakness were outlined. It has been recommended that further research be instituted on how science process skills affect conceptualization of new science facts and also on ways that encourage proficient in science process skills.

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APPENDIX A: LEARNER QUESTIONNAIRE

WITS UNIVERSITY

RESEARCH INSTRUMENT ON THE FULLFILLMENT OF MSC SCIENCE EDUCATION

THE UTILIZE OF SCIENCE PROCESS SKILLS BY PHYSICAL SCIENCE LEARNERS: A CASE STUDY OF TWO SCHOOLS IN GAUTENG PROVINCE, SOUTH AFRICA

STUDENT NO: 1262320

Important Ethical Issues

1. The results of this research are utilized for research purposes only.
2. The learner is not coerced to answer the research but done out of good will to assist the researcher in studying the utilize science process skills

SECTION A: BACKGROUND INFORMATION

GENDER MALE ☐ FEMALE ☐

AGE ☐ GRADE ☐

CIRCLE THE CORRECT RESPONSE

Science process skills divided into basic and integrated science process skills: Basic science skills include (i) classifying, (ii) communicating (iii) observing, (iv) measuring and using numbers, (v) predicting, (vi) making inferences, Integrated science process skills consist of (i) interpreting data, (ii) making hypotheses, (iii) calculating, (iv) controlling variables, and (v) experimenting	
1.	Where do you normally utilize science process skills A. School B. Parents C. Friend D. Internet E. None
2	When did you first started actively using science process skills A. Primary B. High School C. Friends
3	How would you rate your ability to utilize science process skills A. Very low B. Low C. Average D. High E. Very High
4.	How frequent does your teacher utilize them in class

	A. Very low usage B. Low usage C. Average usage D. Good usage E. Very good usage

SECTION B: RATING ON THE UTILIZE OF SCIENCE PROCESS SKILLS

On this section the researcher will explain to the learners the key word for each item concerning utilize of science process skill, e.g. all the words below that are in capital letters such as IDENTIFY, CLASSIFY, COMMUNICATE ……

Rating questions about science process skills	**Rarely**	**Sometimes**	**Fair**	**Often**	**Always**
5. I can utilize and able to **IDENTIFY** important things or problems in Physical Science i.e. I can identify topics in Physical Science and able to work out some questions					
6. I can utilize and I am able to **CLASSIFY** the observed Physical Science features, e.g. able to classify scalar quantities and vector quantities or to classify acids and bases					
7. I can utilize and I am able to **COMMUNICATE** learned information, e.g. to draw maps, charts, symbols, graphs and diagrams to communicate the information.					
8. I can utilize and I am able to draw or link **DIAGRAMS** in Physical Sciences to the everyday life, i.e. science activities or diagrams from newspapers and magazines.					
9. I can utilize and I am able to do activities in which I can **COMPARE** objects using standardized units of measure and suitable					

measuring instruments e.g. ruler					
10. I can utilize and able to **OBSERVE** and read Physical Science phenomena such as maximum and minimum temperatures, mass of objects and identify elements on the periodic table etc.					
Rating questions about science process skills	**Rarely**	**Sometimes**	**Fair**	**Often**	**Always**
11. I can utilize and able to **PREDICT** future Physical Science events based on my observations					
13. I can utilize and I am able to utilize various forms of data to do **CALCULATIONS** of Physical Science questions or issues					
14. I can utilize and I am able to **DESCRIBE** a Physical Science activities like equations, topics and periodic table					
15. I can utilize and I am able to do exercises in which I have to **CONSTRUCT TABLES OF DATA**.					
16. I can utilize and I can devise exercises in which my learners have to **CONSTRUCT GRAPHS OR TABLES** or maps in Physical Science					
17. I can utilize and I am able to do exercises in which I **CONDUCT INVESTIGATIONS** like identifying the variables under investigation, taking readings for independent and dependent variable					
19. I can utilize and I am able to do Physical Science problems in which I am required to **CONSTRUCT HYPOTHESES**					

20. I can utilize and I am able to do science practical in which I **CONDUCT EXPERIMENTS with science apparatus**					
21. I can utilize and I am to **DESIGN INVESTIGATIONS** to test the given hypotheses.					
22. I can utilize and I am able to do exercises in which I have to **describe the RELATIONSHIP BETWEEN VARIABLES** on a graph.					

SECTION C: PROBING ON IMPACT OF SCIENCE PROCESS SKILLS ON PERFOMANCE AND VITAL ISSUES OF SPS

23.	To what level do you think these science process skills can assist you to understand new science topics A. Very low assistance B. Low assistance C. Average D. High assistance E. Very High assistance
24	To what extent do you think science process skills can assist you to perform better in science examinations A. Very low performance B. Low performance C. Average D. High performance E. Very high performance
25	How would you rate your frequency of usage of these science process skills A. Very low B. Low

	C. Average often D. High E. Very High
26.	What are the possible hindrances on the utilize of science process skills A. My poor background of Physical Science issues B. My teacher do not assist me to develop science process skills C. Lack of resources at school D. I do not have interest to utilize science process skills E. I do not have any hindrances on using science process skills

APPENDIX B: LEARNER INTERVIEW SCHEDULE

STAGE TWO OF THE RESEARCH. FOLLOW UP IN-DEPTH INTERVIEWS WITH PHYSICAL SCIENCE LEARNERS

1	**Which science process skills are you familiar with and which ones do you utilize mostly. Name them and explain** …… …… …… …… …… …… …… …… …… ……
2	**How often do you utilize or apply science process skills. Discuss** …… …… …… …… …… …… …… …… …… ……
3	**To what extent do science process skills assist you to pass science examinations** …… …… …… …… …… …… …… …… …… ……
4	**What are the possible hindrances on the utilize of science process skills by Physical Science learners** …… …… …… …… …… …… …… ……

APPENDIX C: TEACHER INTERVIEW SCHEDULE

STAGE TWO OF THE RESEARCH. FOLLOW UP IN-DEPTH INTERVIEWS WITH PHYSICAL SCIENCE TEACHERS

1	**How do you ensure science process skills are utilized by learners. Explain** …… …… …… …… …… …… …… …… …… ……
2	**How do learners copy with the utilization of science process skills. Discuss** …… …… …… …… …… …… …… …… …… ……
3	**To what extent do science process skills assist science learners to pass examinations? How much do they assist** …… …… …… …… …… …… …… ……
4	**What are the possible hindrances on the utilize of science process skills by Physical Science learners** …… …… …… …… …… …… …… …… …… ……

APPENDIX D: LESSON OBERVATION SCHEDULE

Name of SPS **Basic SPS**	**Learner**	**School A**			**School B**		
		Poor Performance	**Fair**	**Good Performance**	**Poor Performance**	**Fair**	**Good Performance**
Classification	**Learner 1**						
	Learner 2						
Communication	**Learner 1**						
	Learner 2						
Observation	**Learner 1**						
	Learner 2						
Comparison	**Learner 1**						
	Learner 2						
Identification	**Learner 1**						
	Learner 2						
Describing	**Learner 1**						
	Learner 2						
Drawing	**Learner 1**						

	Learner 2						
	Learner 2	**X**					

Integrated SPS- Observation Schedule

Name of SPS	**Learner**	**School A**			**School B**		
		Poor Performance	**Fair**	**Good Performance**	**Poor Performance**	**Fair**	**Good Performance**
Prediction	Learner 1						
Designing hypothesis	Learner 2 Learner 1 Learner 2						
Experimenting	Learner 1 Learner 2						
Relationship between variables	Learner 1 Learner 2						
Controlling Variables	Learner 1 Learner 2						

APPENDIX E: ETHICS APPROVAL LETTER: GAUTENG DEPARTMENT OF EDUCATION

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no: D2016 / 265
enquiries: Diane Buntting 011 843 6503

GDE RESEARCH APPROVAL LETTER

Date:	**4 September 2015**
Validity of Research Approval:	**4 September 2015 to 2 October 2015**
Name of Researcher:	**Chigumbura B.**
Address of Researcher:	**P.O. Box 495; Mothibistad; 8474**
Telephone / Fax Number/s:	**074 755 4691**
Email address:	**chigumburabi@yahoo.co.uk**
Research Topic:	**The use of Science process skills by Physical science learners: A case study of two schools in Gauteng Province, South Africa**
Number and type of schools:	**TWO Secondary Schools**
District/s/HO	**Ekurhuleni South and Johannesburg Central**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved. A separate copy of this letter must be presented to the Principal, SGB and the relevant District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted. However participation is VOLUNTARY.

The following conditions apply to GDE research. The researcher has agreed to and may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

CONDITIONS FOR CONDUCTING RESEARCH IN GDE

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter;
2. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB);

Makhado
2015/09/07

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Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za

APPENDIX F: ETHICS APPROVAL LETTER: ETHICS APPROVAL LETTER: WITS UNIVERSITY

Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 Private Bag 3, Wits 2050, South Africa. Tel: +27 11 717-3064 Fax: +27 11 717-3100 E-mail: enquiries@educ.wits.ac.za Website: www.wits.ac.za

02 October 2015

Student number: 1262320

Protocol Number: 2015ECE045M

Dear Brian Chigumbura

Application for Ethics Clearance: Master of Science

Thank you very much for your ethics application. The Ethics Committee in Education of the Faculty of Humanities, acting on behalf of the Senate, has considered your application for ethics clearance for your proposal entitled:

The use of Science process skills by Physical Science learners: A case study of two schools in Gauteng province, South Africa

The committee recently met and I am pleased to inform you that **clearance was granted**.

Please use the above protocol number in all correspondence to the relevant research parties (schools, parents, learners etc.) and include it in your research report or project on the title page.

The Protocol Number above should be submitted to the Graduate Studies in Education Committee upon submission of your final research report.

All the best with your research project.

Yours sincerely,

Wits School of Education

011 717-3416

cc Supervisor - Prof. Elaosi Vhurumuku