THE DEVELOPMENT OF LEARNERS' SCIENCE PROCESS SKILLS, KNOWLEDGE AND STIMULATION ON TEST FOR REDUCING SUGARS WHEN USING MSL KITS IN SELECTED SECONDARY SCHOOLS IN CHINSALI DISTRICT

BY

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A dissertation submitted to the University of Zambia in partial fulfilment for the requirement for the award of the degree of master of education in science education.

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DECLARATION

I, **Nkole Catherine Mutale**, do hereby declare that this dissertation is my own work, and that all the works of other persons used have been duly acknowledged, and that it has never been previously submitted for a degree at the University of Zambia or any other University.

Signature: ……………………………………

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APPROVAL

This dissertation of **Nkole Catherine Mutale** is approved as partial fulfilment of the requirements for the award of the degree of Master of Education in science Education by the University of Zambia.

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DEDICATION

This work is dedicated to my husband Mr. Martin Musaba, my two lovely sons Mwewa Musaba and Chisanga Musaba, my two lovely daughters Chongo Musaba and Mutale Musaba. Their presence gave me hope and encouragement both spiritually and emotionally during this study.

To my father, Mr Peter Chisanga Nkole and my late mother MHSRIP Mrs Emelia M. Bwalya Nkole, I will always pave way for my siblings. Above all, my mum Mrs Sabina Bwalya C. Chansa I will always remember the encouragements and hope you gave me more especially when you said "my daughter do not lose hope, remain focused and concentrate on your education for your dreams to be realised." I will always endeavour to uphold your wise counsel. Thank you for believing in me.

ABSTRACT

This study investigated the development of learners Science process skills, knowledge and stimulation on testing food for reducing sugars when using the Mobile Science Laboratory (MSL) kits in selected schools of Chinsali District. The main objectives were to determine the appropriate science process skills (SPS) developed, to establish the knowledge acquired and to ascertain the stimulation attained by learners in a practical test on reducing sugars when using the MSL kits. The research design used was the concurrent triangulation design and therefore, a mixed method approach was used. Purposive sampling was used to select the participating schools on the ground that they possessed the MSL kits and that they were government schools. Stratified random sampling was used to come up with two strata, grade 11s and grade 12s. Data collection was done through quantitative and qualitative approaches using questionnaires, observation schedule and interview schedules. The study sample was 179 participants consisting a total of 166 learners, Heads of Natural Sciences Departments were 4, and 9 teachers of Biology. Of the 166 pupils 55 were female and 111 were males. All the participants were drawn from the selected upgraded secondary schools that received MSL kits. Questionnaires were administered to all the 179 participants. A total of 14 lessons were observed and 61 pupils along with 9 teachers were interviewed. Data obtained from both the questionnaires and observation schedule were analysed quantitatively. SPSS software version 20 was used to generate descriptive statistics and test for significant difference by way of independent t-test and one way ANOVA. All statistical tests were evaluated at 95% confidence interval. Thematic content analysis was used for qualitative data. The results from all the three instruments showed that learners developed the appropriate SPS, acquired the appropriate knowledge and attained stimulation while using the MSL kits when testing for Reducing Sugars. The t.test indicated that there was no statistical significant difference between the teachers and learners responses (for SPS $t=1.26$; $df = 177$; $p= .209$, for knowledge $t= .675$; $df = 177$; $p= .501$, for stimulation $t= .213$; $df = 177$; $p = .828$).However one way ANOVA showed a significant difference in the acquisition of knowledge and stimulation (SPS $F(3,162) = 2.44$; $p = .069$, knowledge $F(3,162) = 9.71$; $p= .000$; stimulation $F(3,162) = 10.52$; $p = .000$). The researcher recommends that more MSL kits should be procured and be distributed to all newly upgraded Secondary Schools to improve the teaching of science; Teachers to be conducting regular Practical sessions using MSL kits with learners for them to acquire the SPS; Teachers of biology to ensure learners are exposed more to hands on activities using MSL kits to relate theory to practice. Further research should be done in other Districts of the country to verify these findings in order to arrive at a more definite decision regarding the use of MSL kits in the practical test on reducing sugars.

Key words: ***Mobile science laboratory, Science Process Skills, Knowledge, Stimulation***

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

AAAS	American Association for Advancement of Science
ANOVA	Analysis Of Variance
DEBS	District Education Board Secretary
ECZ	Examination Council of Zambia
HOD	Head of Department
ILM	Intellect Love Mercy
JICA	Japan International Cooperation Agency
MLC	Mobile Laboratory Coalition
MOGE	Ministry of General Education
MSL	Mobile Science Laboratory
MV	Mamidipudi Venkatarangaiya
NSC	National Science Centre
OTEC	. Oregon Technology in Education Council,
PEO	Provincial Education Officer
PP	Participating Pupils
PT	Participating Teachers
RADMASTE	Research and Development in Maths, Science and Technology Education
SPS	Science Process Skills
SPSS	Statistical Package for Social Sciences
STEM	Science Technology Engineering and Mathematics

OPERATIONAL DEFINITIONS

Knowledge:	Knowledge is the conceptual understanding in relation to the topical content on reducing sugars.
Mobile Science Laboratory kit:	A self-contained mobile unit which can be moved from one class to another and is preloaded with chemical reagents and apparatus
Reducing sugars:	Simple sugars e.g. glucose that can reduce copper (11) ions blue in colour to copper ions-reddish in colour.
Science process skills:	SPS in this study were, observation, measuring, classifying, predicting, inference, communication and experimenting.
Stimulation:	Motivation attained by learners during the practical lesson on reducing sugars and the interest exhibited to pursue biology related careers.

CHAPTER ONE: INTRODUCTION

1.1 Overview

The research was aimed at assessing the developed science process skills, knowledge and stimulation in learners on test for reducing sugars when using the Mobile Science Laboratory (MSL) kits with a focus on selected secondary schools in Chinsali District. This chapter presents the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, and significance of the study. It further highlights the limitation of the study and the operational definitions of key terms.

1.2 Background

During the 1980s there was an introduction of basic education system in Zambia. This brought about an increase in the number of learners going to secondary schools, consequently the scenario led to a number of operational logistical challenges. Ranking high amongst them was the provision of practical science education since the upgraded schools had no provision for this (Sambala, 2017). Table 1.1 shows a definite increase in the learners in science subjects.

Table 1.1: Trends in candidature in the natural science subjects from 2011 to 2015

Year	**2011**	**2012**	**2013**	**2014**	**2015**
Candidature	84,810	98,622	99,504	113,19	119,72

Source: Ministry of General Education (2016)

Despite this increase, even by the year 2013 most of the upgraded secondary schools did not have conventional laboratories to support practical aspect of teaching and learning science. Science subjects form a very important component of the secondary school curriculum as they are a hallmark of development- the reason why all learners in secondary schools are expected to take science subjects (MOGE, 1996).

One of these subjects is biology which is taken by majority of learners. It is examined as biology paper1 (5090/1) multiple choice, biology paper 2 (5090/2) structured and essay type questions and biology paper 3 (5090/3) practical paper. All these papers contribute marks to the final grade in biology. Paper1 contributes 40 marks, paper 2 contributes 60 marks and paper 3 contributes 40 marks. Biology is a pre-requisite to entering science related fields such as engineering, medicine, agriculture and scientific research (ECZ, 2017). However, the performance of candidates in biology has not been good as it has continued to record a mean score of below 40%. For example, in 2015 the mean score was 21.59 % while 2016 the score was 24.14 % (ECZ, 2016). Table 1.2 shows that the raw mean score in biology from 2012 to 2015 reduced to below 40 from 42.19 in 2011.

Table 1.2: Trends in the raw mean score in Biology from 2011 to 2015

Year	2011	2012	201 3	2014	2015
Mean	42.19	36.22	39.79	34.19	34.55

Source: Ministry of General Education (2016)

The poor performance is attributed to challenges learners encounter in biology practicals (ECZ, 2016). Learners have challenges with making observations and undertaking critical analysis of their observation in paper 3(5090/3). This paper requires them to perform an activity, observe, and draw conclusion from the observations (ECZ 2016). This is also revealed in the study which was conducted by Haambokoma *et.al* (2002) in which teachers and learners found certain topics in biology practical difficult to teach and learn respectively, specific areas cited were food tests.

Food tests conducted in secondary school biology (5090/3) are; test for starch, test for proteins, test for lipids, test for reducing sugars and test for non-reducing sugars. Statistics show that the food test on reducing sugars comes often in the final practical examinations. Table 1.3 shows the frequency of food test during grade 12 biology final practical exams.

Table 1.3: Frequency of food test during grade 12 biology final practical examinations from 2009 to 2017

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Test for starch		|		|		|			
Test for proteins						|	|	|	
Test for lipids									
Test for reducing sugars	|	|		|		|	|		|
Test for non-reducing sugars									

Source: Examination Council of Zambia (2018)

It is evident from Table 1.3 that the most frequent food test examined in biology (5090/3) is reducing sugars.

For this reason, the researcher perceived that the food test on reducing sugars embedded more science process skills (SPS) than other food tests. The SPS include, observing, classifying, measuring, communicating, inferring, predicting, and experimenting (Muzumara, 2008). The American Association for Advancement of Science (AAAS) identified twelve SPS which include observing, measuring, classifying, communicating, predicting, inferring and experimenting (AAAS, 2011).

The SPS under consideration in this study were observation, measuring, classifying, communication, predicting, experimenting and inference. These were considered with the view that during the practical test on reducing sugars, learners were socialising while learning was taking place thus bringing about behavioural and cognitive change

Integration of SPS in teaching has been noted to improve students' performance in biology (Abungu, 2014, Chebii, 2008, Myers, 2004). It also assist students to retrieve prior knowledge and anchor new incoming information in their cognitive frame work

(Dennis, *et.al* 2017). Therefore, the SPS developed in learners during the practical test on reducing sugars when using the MSL kits would improve learners' performance. This is because SPS are vital in the retrieval and anchoring of information in the cognitive framework. This would further enable learners to handle the biology final exams without challenges.

If the SPS are not developed sufficiently, students cannot interpret knowledge (Karamustafauglo, 2011). This implies that having these SPS developed then the appropriate knowledge could also be developed as there will always be a stimulus to motivate learners.

Knowledge is said to be the foundational cognitive skill which refer to the retention of specific information (Gagne, 1985). It is the simplest and the first one to be developed in learners. Additionally, it is a lower order Blooms skills because learners were building foundational knowledge (Blooms, 1956). Therefore, the knowledge which was acquired would enable learners to handle further topics at a higher level especially tertiary education without challenges as they would have already acquired the foundational knowledge.

Laboratory activities are essential in teaching science as it stimulates interest, develop learners' scientific skills and improve learners' mastery of subject matter (Dillon, 2008). Additionally, Mobile Science Laboratory (MSL) improve knowledge and academic performance of students in science (MV Foundations, 2012). Therefore, the use of the MSL kits in newly upgraded secondary schools would as well stimulate learners' interest and improve their mastery of subject matter. In this case the subject matter is referring to the knowledge in relation to the practical test on reducing sugars. This would further help in improving learners' performance.

However, a number of researches have been conducted and highlighted among others, lack of conventional laboratories as contributing to low performance (Nkoya, 2008 and Chocha *et.al,* 2014). In addition, the absence of laboratory equipment means learners would not be able to conduct practical experiments as required in the curriculum which would adversely affects their overall performance and understanding of the subject matter, Maseko (2014).

To curb this notion, the Ministry of General Education (MOGE) through the National Science Centre (NSC) with the help of Japanese International Cooperation Agency

(JICA) has embarked on the production and distribution of MSL kits to schools country wide. It has also trained some science teachers on how to use these MSL kits. So, while practical lessons can be done in conventional laboratories, they can also be conducted using MSL kits.

A MSL is a self-contained mobile unit that can be used in multiple classrooms, it is a compact platform for educators and learners to demonstrate and conduct experiments designed to move from one classroom to another with convenience Maseko (2014). Figure 1.1 shows a picture of a MSL kit captured from NSC

Figure 1.1: A mobile science laboratory (MSL) kit
Source : National Science Centre - Lusaka (2018)

This is the type of MSL kits that have been distributed to newly upgraded secondary schools of Chinsali District. Egawa (2013) asserted that each of the 10 provinces got 100 MSL kits which were distributed to secondary schools. Additionally, Egawa (2013)

claimed that these MSL kits would make the teaching of science more effective with the combination of theoretical and practical, experiment-oriented lessons. He further added that these kits were to significantly enhance the aspect of science teaching and learning at the beneficiary secondary schools. However, the findings by (Changwe, 2008) revealed that Science kits that were introduced to Zambian basic schools in 2003 were not being used in the teaching and learning science. This did not reinforce learners understanding through experimentation and not motivated to learn science.
It is therefore against this background that this study was developed.

1.3 Statement of the Problem

It is not clear how effective the MSL kits have been on learners' development of appropriate SPS, knowledge and stimulation.

The continuous poor performance as highlighted in Table 1.2 has been attributed to lack of in depth knowledge required to give correct responses to the demands of the question. Some candidates also fail to make accurate observations, measurements and conclusions (ECZ, 2015). This study therefore, is an attempt to determine the learners developed SPS, knowledge and stimulation during a practical test on reducing sugars when using the MSL kits.

1.4 Purpose of the Study

This study intended to explore the SPS, knowledge and stimulation developed by learners during the practical test on reducing sugars when using MSL kits in selected schools in Chinsali District of Muchinga Province.

1.5 Objectives of the study

The objectives of the study were to:

1) Determine the appropriate SPS developed by learners during the practical test on reducing sugars when using MSL kits?
1) Establish the knowledge developed by learners during the practical test on reducing sugars when using MSL kits?

2) Ascertain the stimulation developed by learners during the practical test on reducing sugars while using the MSL kits.

1.6 Research Questions

In this study three questions were addressed.

2) What are the appropriate SPS developed by learners during a practical test on reducing sugars when using MSL kits?
3) What knowledge is developed by learners during a practical test on reducing sugars when using the MSL kits?
4) What stimulation is developed by learners during a practical test on reducing sugars when using the MSL kits?

1.7 Significance of the Study

This study would add value to the teaching of macro molecules in biology and to the teaching of biology content by providing teachers, MOGE, Japanese International Cooperation Agency (JICA) and other stakeholders with the information on the appropriate SPS, knowledge and stimulation developed by learners during a practical test on reducing sugars when using the MSL kits.

Consequently, the Government through the National Science Centre (NSC) might learn of adjustments to make in the contents of the MSL kits in terms of reagents and apparatus. The findings might as well help donor agencies like the JICA to appreciate the contribution they render to the Science Education in Zambia. In addition, it would enable teachers to be enlightened on the fundamental outcomes of using MSL kits.

Also, the research would provide a useful baseline data about the use of MSL kits during a practical test on reducing sugars in Chinsali District of Muchinga Province of Zambia that can be used to be expanded upon in future studies especially for rural and newly upgraded secondary schools.

Furthermore, since the use of MSL kits is new in Zambia, the study might as well help bridge the knowledge gap in the use of the MSL kits and supplement the existing literature on the behaviourist and cognitive learning approaches.

1.8 Study scope

The study was confined to four newly upgraded secondary schools in Chinsali District of Muchinga province. These were selected on the basis of having MSL kits.

1.9 Limitation of the Study

Many learners had the problem in expressing themselves fluently in English during interviews, this made it difficult at some point for the researcher to understand what some participants were trying to say. The other contributing factor was that; the researcher had limited time and could not involve participants from other schools. Finally, a larger sample size was not achieved due to financial constraints. Therefore, this study might not aim to attain a representation and generalization, but to get a deeper understanding and description of the use of MSL kits during a practical test on reducing sugars, and the appropriate SPS, knowledge and stimulation developed by the learners.

1.10 Theoretical Framework

This study was guided by Bandura`s social learning. This theory posits that people learn from one another, via observations, imitations and modelling. This theory has often been called a bridge between behaviourist and cognitive learning theories because it encompasses attention, memory, and motivation (Bandura, 1977).

In this study learners passively paid attention when receiving instruction from their teacher and receiving is about memory, if memory lacks then no learning occur (Gagne & Robert, 1975).

Therefore, during the practical test on reducing sugars when using the MSL kits the teacher had to demonstrate and later gave instructions to the learners. During demonstration learners paid attention and later imitated the teacher, this was possible because of memory which triggered learning and behavioural change in learners.

The students participated in the learning process by not only attending to the stimulus but also reacting in some way and recognising their abilities and limitations; they further showed their desire to learn new processes (motivation) (Gagne & Robert, 1985). In view of this, the researcher believed that SPS were developed alongside with knowledge and stimulation.

Teaching should transition from simple lower levels (behaviourism) to complex higher levels (cognitivism) (Gagne & Robert, 1975; 1985). During the practical lesson on reducing sugars learners gained knowledge which was personal knowledge embedded in their individual experience. Socialisation arose as sharing experiences to create tacit knowledge which includes observation, imitation and practice (Nonaka & Tekeuchi, 1995).

The practical test on reducing sugars draws both behaviourism and cognitivism. In line with this, the researcher rooted the study on Banduras social learning theory because during a practical test on reducing sugars, learners were learning from one another, especially their teacher through observations by paying attention when using the MSL kits, learners were involved in a lot of observations on the practical proceedings in terms of apparatus arrangement and precaution measures. Following these observations, learners reciprocated the teacher. For this to be achieved, learners had to pay attention to what their teachers were demonstrating and they had to have a good memory. Learning results when information is stored in memory in an organised meaningful manner Jonassen (1991). The researcher believed this would result in modelling learners because then, they would be able to imitate the teacher as supported by Gunstone and Champagne (1990) that; meaningful learning in the laboratory would occur if students were given sufficient time and opportunities for interactions and reflections.

Once learners incorporate the cognitive domains of analysing, synthesising, or the subject matter, there should be an increase in their grades resulting in enhanced academic retention and higher self-efficacy, as well as self-esteem (Cruz, 2003). In view of this, the researcher believed that the interactions in the laboratory would bring about behavioural and cognitive change in learners. Additionally, the cognitive theories emphasize making knowledge meaningful and helping learners organise and relate new information to existing knowledge in memory (Jonassen, 1991).

This theory being a bridge between behaviourist and cognitivist made the researcher believe that as learners were conducting the practical test on reducing sugars they were provided with opportunities that encouraged them to ask questions indicating that communication as one of the SPS and other SPS were developed. As learners got more involved in the laboratory activities they constructed their ideas and understanding of the series of personal experiences (Lunetta, 1998). All this implied that Banduras theory was of great significance to this study. Hofsten *et.al*, (1982), suggested that laboratory work was an important medium for enhancing attitudes, stimulating interest and enjoyment, and motivating students to learn science.

During the observations (refer to Appendix E), the researcher realised that learners enjoyed the practical lesson on reducing sugars when using the MSL kits. Laboratory activities have the potential to enhance constructive social relationship as well as positive attitude and cognitive growth, (Hofsten *et.al*, 1982 Lazarowitz *et.al*, 1994).

Enjoyment implied that learners were stimulated. Therefore, cognitive growth in this case was attributed to conceptual knowledge which was as a result of interactions during the practical activities which involved the SPS (observation, communication, predicting, inference, experimenting, measuring). As learners were conducting the practical test on reducing sugars apart from observations, they were communicating with either the teacher or their fellow friends and as such, they were able to predict the outcome of the experiment and able to make inferences. This resulted in the development of the SPS.

Finally, the use of MSL kits during a practical test on reducing sugars with learners fully engaged would trigger their self-esteem, intrinsic motivation and above all, being modelled into curious learners, leading to stimulation with increased conceptual and scientific knowledge.

1.12 Organisation of Dissertation

The study is composed of five chapters. Chapter One is the general research background stating the statement of the problem, the research objectives and questions, the purpose of the study, the significance of the study, the study scope, the limitations of the study and the theoretical framework. It further highlights the operational definitions and the research outline. The second chapter presents the review of related literatures. The third chapter is all about research design and methodology of the study conducted. Results and discussion are described under chapter four. Chapter Five is about summary of major findings. Finally the conclusions and recommendations are in Chapter Six.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviewed literature related to the study and is organised by the following headings: The role of conventional science laboratories in secondary schools; Students learning through investigations; Empirical literature review; Summary of the chapter.

2.2 The role of conventional science laboratories in secondary schools

A laboratory is a facility equipped and competent to conduct scientific experiments, observations, tests, and investigations. It is a special room for scientific experiments with special tools and equipment called apparatus (Babalola, 2017). Conventional science laboratories in this regard are special rooms in schools constructed specifically for practical science activities. These facilities exist in nearly all government constructed secondary schools.

Motlhabane and Dichaba (2013), asserts that, studies conducted globally have shown the pivotal role by laboratory work in enhancing science concepts' teaching and learning in educational institutions. This is evident that the use of science laboratories enables learners to understand the concepts.

Jokiranta (2014) adds that, using laboratory work as a teaching strategy has many rationales and highlighted objectively as follows; to help students develop their knowledge of the world and their understanding of some of the main ideas, theories and models that science use to explain it, and to help students learn how to use piece(s) of scientific apparatus and /or to follow some standard scientific procedure (s). A laboratory is viewed as the essence of science. In this regard, the researcher strongly believed that the use of MSL kits helped learners to use apparatus and follow scientific procedures when conducting the practical test on reducing sugars. Laboratory activities have been regarded as an important part of science education.

In contrast, evidence suggests that laboratory activities fall short on achieving the potential for enhancing student learning with understanding (Hofstein and Lunetta, 1982; Stake and Easley, 1978; Tobin and Gallagher, 1987). The assertions from these scholars seem not to be in line with most scholars.

Researchers have found science laboratories to be central to the teaching of science in secondary schools (Adeyemi, 1998; Ige, 2000). In addition, laboratories have been found to be the scientists' workshop where practical activities are conducted to enhance a meaningful learning of science concepts and theories (Seweje, 2000; Olubor and Unyimadu, 2001). Therefore, the use of MSL kits during the practical test on reducing sugars enhanced learning. Learners were exposed to a series of activities involving SPS to yield the appropriate knowledge.

Laboratories have also been found to be a primary vehicle for promoting formal reasoning skills and students understanding, thereby enhancing desired learning outcomes in students (Jeske, 1990; Ogunleye, 2002). Jones (1990) examined teachers' provision in the sciences in many countries and found 45% of the schools surveyed indicated insufficient laboratories. His findings agreed with the findings of Barrow (1991), in Saudi Arabia which indicated inadequacy in the provision of laboratory in schools. The findings were also consistent with those of Black and Williams (1998) who found in Uganda that science education is faced with the problem of lack of resources with half the schools having no real laboratory. The situation is similar in Zambia where most newly upgraded secondary schools do not have science laboratories but have been provided with MSL kits to enhance the teaching of science.

Researchers have found shortages in the number of laboratories in Nigerian schools (Alebiosu, 2000; Onipede, 2003). They argued that many schools did not have required laboratory facilities, hence students failed to acquire science laboratory skills because their teachers were unable to conduct practicals as they would like to and this always had inevitable consequences for students learning (Keister, 1992). These shortages of laboratory facilities could have serious implications on the quality of schools output. A study conducted by Ndihokubwayo (2017), in Rwanda to investigate the status and barriers of science laboratory activities in teacher training colleges towards improvisation practice revealed that; students who had laboratory at school reported that experiments were done mostly in laboratory rooms and outside classrooms. Ndihokubwayo further indicated that; students who did not have laboratories at school reported that experiments were not done. In addition, teachers revealed that it was difficult to conduct experiments because of no science laboratories at school. This being the case in most Zambian schools necessitated this study.

Stein (1998), cited laboratories as examples in which students are involved in activities which replicate actual work settings. Clancey (1995) claimed that students were more inclined to learn by actively participating in the learning experience. Therefore, knowledge acquisition becomes a part of the learning activity (OTEC, 2007.) Most science teachers perceive that laboratory activities are essential in teaching science as it stimulates interest as well as developing their scientific skills (Dillon, 2008). Since the MSL kits are being used in place of conventional laboratories in the teaching of science, the researcher strongly believed that these kits stimulated interest in learners.

In addition, Hofstein and Lunetta (1982) suggested that laboratory activities could be effective in promoting intellectual development inquiry, and problem solving skills. Further, they claim that laboratory activities could assist in the development of observational and manipulative skills and in understanding science concepts. Therefore, the use of the MSL kits during the practical test on reducing sugars can as well enable learners to develop SPS, knowledge and stimulation

Studies conducted about laboratory experiences and student learning as revealed in the Americas lab report (2006) indicated that; laboratory experiences showed greater effectiveness in improving students' mastery of subject matter, increased development of scientific reasoning and enhanced interest in science. Moreover, Laboratory experiences cultivated interest in learning science. Laboratory experiences developed team work abilities to collaborate effectively with others in carrying out complex tasks and to assume different roles at different times.

With the MSL kits experiences learners learnt to use the apparatus. They developed skills of using scientific equipment correctly and safely, making observations, taking measurements and carrying out well defined scientific procedures.

However, one study found that students were often deficient in skills such as using instruments, making measurements and collect accurate data (Bryce & Robertson, 1985). Other studies indicate that helping students to develop relevant instrumentation skills in controlled "prelab" activities can reduce the probability that important measurements in a laboratory experience will be compromised due to students' lack of expertise with the apparatus (Beasley, 1985; Singer, 1977). In a similar view Jones (2017) indicated that integrated laboratory experiences have the potential to expand student learning beyond the simplified instruction presented in lectures and reading, thereby allowing students to master complex science topics. In this view, the provision of MSL kits in teaching and learning science would enable learners to relate theory to practice resulting in concept mastery. Schools that combine classroom teaching with laboratory experiments ensure that their learners grasp each and every concept thoroughly. Laboratory teaching and experiments conducted helped encourage deep understanding in learners. Learners are able to retain the knowledge for longer periods when they see the experiments being performed in front of their eyes.

It is significant for schools to have the latest science laboratory supplies and equipment to make science interesting and effective for students and to encourage them to make relevant contributions in the field of biology and, other streams of science later in life. Some research on laboratory experience indicates that girls handle laboratory equipment less frequently than boys and this tendency is associated with less interest and less self confidence in science ability among girls (Jovanovich & King 1998). Therefore, the use of MSL kits in newly upgraded secondary schools would enhance both boys and girls to have laboratory experiences which would lead to them develop SPS, knowledge and stimulation.

2.3 Students Learning Through Investigations

It is hard to imagine learning science without doing any laboratory activities or field work. Experimentation underlies all scientific knowledge. Laboratories are wonderful settings for teaching and learning science. They provide students with opportunities to contemplate, discuss, and solve real problems. Developing and teaching in an effective laboratory requires as much skill, creativity, and hard work. In science education, laboratories supplied learning opportunities for abstract subjects (Nakhleh, 1994), improved problem solving abilities and psychomotor skills (Hofstein, 2004; Singer *et al*. (2005), and increased the classroom motivation Telli et *al.* (2004). According to Çepni et *al*. (1995), laboratory activities improved reasoning and critical thinking abilities in science and provided opportunities to understand the nature of science. Klemm and Plourde (2003) stated that experiments helped students to develop various skills related to science learning.

The use of hands-on activities is one of the experimental learning approaches involving practices that can be carried out by using inexpensive equipment. These activities are quite suitable for students in the rural outskirts of cities and provide equity between students in different economic settings, because they can be implemented with simple and cheaper materials (Uysal & Eryılmaz, 2002). Hands-on experiments improve students' academic success, allow them to develop positive attitudes towards science (Bredderman, 1983; Shymansky, *et al* 1983; Shymansky *et al* 1990; Yu & Bethel, 1991), and facilitate students' learning of science concepts. These experiments also help them to acquire problem solving and scientific thinking skills (Leung, 2008). These activities develop science process skills and an understanding of the nature of science (Başdaş, 2007).

2.4 Empirical literature review

The researcher believes that any facility used for teaching and conducting practical science activities in place of a conventional science laboratory is considered to be a non-conventional science laboratory. The shortage of conventional science laboratory facilities brought about serious implications on the teaching and learning of science. This prompted a lot of researchers and scholars to intervene in this matter by introducing nonconventional science laboratories. For example, the Research and Development in Maths, Science and Technology Education (RADMASTE) was founded in November 1990 whose aim was to improve the quality and relevance of practical activities. It recognised the pathetic status of practical activities which was apparently a global problem. The micro science kits were then conceived by RADMASTE as a response to this problem and between 1993 and 1995 Somerset educational manufactured these kits. More than 80 countries have been introduced to some of the RADMASTE micro science kits and activities. Pilot projects have been initiated and learners can work in an ordinary classroom with ordinary desks (Bradley & King, 2015). For example, Bradley (2015) proposed that in South Australia, at Unley high school in Adelaide the senior teachers created a dynamic learning environment by using movable tables. In Switzerland, in junior secondary schools in Canton of Geneva, chemistry, physics and biology were taught in "versatile" classroom where all equipment was mobile. According to Intellect Love Mercy (ILM) foundations (2017), Vidnyanvahini a non-profit making organisation has reached out to rural school children to offer them a means of learning science through MSL experiments. Its objectives are:

i. To provide rural school children with an opportunity to handle scientific apparatus and learn the basics of science through experiments;

ii. To explain the science behind so seemingly curious results, and thus help remove age-old superstition;
iii. To bridge the gap between rural and urban education;
iv. To spread the message in rural communities that science can help solve the problems in their everyday lives as much as it does to urbanites.

Kisule labs and Technology manufactures MSL since 2009 and supplies, delivers and installs technology kits to rural and urban schools for learners in grade 8-12 (Maseko, 2014). These MSL will address the challenge and stimulates the minds of young learners in the classroom and expose them innovations at an early age. The MSL have been designed in direct response to the challenges and needs of the lack of resources in rural and urban schools. In addition, Maseko described the MSL as a mobile science unit for grade 10-12. It is being tried to up skill learners to understand the science skills so that when they get to the university they would be able to do engineering courses which they are unable to do right now because they lack a good background at primary and secondary school.

A mobile laboratory is a laboratory that is either fully housed within or transported by a vehicle such as a converted bus, or tractor trailer which can serve a function in science education. Mobile laboratories have their own physical facilities that often include laboratory benches, equipment, supplies, fume hoods, electricity, water and other specialised gear to facilitate an engaging, hands-on learning experience for all ages. Jones (2017) indicates that MSL first became popular in the late 1990s with the launch of the Boston University Medical School. Mobile lab in 1998, followed soon after by programs at the University of North Carolina at Chapel Hill. In 2005 these programs joined together to form the Mobile Laboratory Coalition (MLC), which currently has 29 member programs in 17 different states and 2 international locations. Seven states have more than 1-member program.

Throughout history, however several names have emerged to characterise the mobile movement. These names include; circulating exhibition, travelling exhibition, travelling museum, mobile museum, and museum bus, museum on wheels, mobile science laboratories, and mobile science projects (Choi *et.al* 2006).

In Zambia, MSL kits are used because they can easily be accessed by the newly upgraded secondary schools. During the launch of MSL kits by NSC and JICA. Egawa (2013) indicated that MSL kits distributed to upgraded secondary schools countrywide were going to make the teaching of science most effective with the combination of theoretical and practical, experiment-oriented lessons and that these kits were significantly going to enhance the aspect of science teaching in the beneficiary schools.

Sambala (2017), reported that there has been persistent poor performance in science subjects amongst pupils due to lack of laboratories in schools for hands-on science practice. And so, government has embarked on providing mobile laboratories in a bid to counter the trend of poor performance in sciences amongst pupils in the country. In addition, the MSL kits will ensure the provision of science education and help Zambia's attainment of its national vision 2030.

The researcher believes that these are the exact replica of the conventional science laboratories. But they differ in that; the MSL kits can be moved from one classroom to another or even outside and can be used where there are no conventional science laboratories. In view of this, the MSL kits aim at attaining the core function of conventional science laboratories.

The study conducted by the MV foundations in Andhra Pradesh, India suggested that the use of MSL increased students' interest and enthusiasm in science subjects. It also suggested improved students' performance by enhancing their conceptual and practical understanding of the topics taught. The foundation further, indicate that with the use of MSL the average pass mark in science subjects increased across Government schools in India (MV foundations, 2012).

Another project, conducted by Intellect Love Mercy (ILM) foundations (2017), in India proposed that the MSL were to reach out to students and schools that did not have science laboratories. Those were utilised to impart the scientific knowledge to a number of learners. The MSL made it feasible for students and teachers to do hands-on investigations that were not possible in the regular classrooms. The benefit for students benefited increased content knowledge and improved attitude towards science. The ILM foundation further added that through its MSL, students had a chance to learn science by performing experiments, thus giving them not only the pleasure of "learning by doing" but also rendering the subject enjoyable and easy to understand.

Jones (2017), asserted that Mobile Laboratory (ML) programs provide active engagement of students in hands-on science activities that use authentic science tools promote student learning and retention. The use of ML have a significant impact on students' motivation and acquisition of skills as long as the interventions includes active engagements (Pellegrino & Hilton, 2012; Fitzakerley et.al, 2013). A study conducted by Rodeni et.al (2018) indicates that using ML is a strategy for stimulating interest in Science Technology Engineering and Mathematics (STEM) careers. In addition, the study suggested that one third of students indicated that they had always wanted to pursue a STEM-related career, and that another third were considering it. About 14.2 % of students selected the response suggesting that they changed their mind as a result of their experience on the science Adventure lab. This data is encouraging and support the use of this type of outreach as a strategy to stimulate interest in careers in STEM. ML have been recognised by many institutions for improving knowledge and understanding concepts.

A study conducted in United States indicates that hands-on experiments offered by MSL, like Seattle children's science adventure laboratory, have been shown to positively impact test scores and drive interest in STEM subjects. It further illustrated the reach and positive impact of MSL in children. "They felt like being a doctor or scientist was feasible when the cool equipment that scientist and doctors used was right in front of them" Moffat said. In support of this view, Jones (2017) claimed that many of the students were inspired to become doctors, nurses, engineers, scientist, as well, wanted a cure for cancer. It was found that the engagement of kids in science provided really positive experience in elementary school, their interest in learning was sustained all the way through middle school.

However, a study conducted by Changwe (2008), on the use of science kits that were introduced to Zambian basic schools in 2003 indicate that they were not being used in the science teaching and learning environments. Therefore, these science kits did not reinforce learners understanding through experimentation. Further, learners would not be motivated to learn science.

In addition, Hudson (1990, 1996) suggest that laboratory work is often the following of recipe-style instructions, they are at best a waste of time and more likely, they are confusing and counter-productive.

In view of the above assertions, the researcher believes that, using the MSL kits in newly upgraded secondary schools in Chinsali District of Muchinga Province as a teaching strategy during a practical test on reducing sugars would help learners develop their conceptual knowledge, appropriate SPS and stimulation.

Therefore, science practical cannot only be done in conventional laboratories but also using MSL kits. Due to the above claims, the study aims to explore which SPS, knowledge and stimulation are developed by learners during a practical test on reducing sugars while using the MSL kits.

Laboratory exercises that utilise an inquiry-based approach instil scientific skills that are desired in life (Haury, 1993). The researcher feels the use of MSL in Zambian schools can enhance learning as they embrace SPS in learners. Most biological practicals are inquiry based because during the process of learning activities, learners do more observations and make conclusions to support their hypotheses.

SPS are divided into two classes namely; basic and integrated skills. Biology teachers should provide opportunities for learners to learn these skills as they engage in the practical food test on reducing sugars when using the MSL. Process skills include; observing, classifying, measuring, communicating, inferring, predicting, and experimenting (Muzumara, 2008). The AAAS identified at least twelve SPS which include: observing, measuring, classifying, communicating, predicting, inferring, and experimenting (AAAS, 2011). Karamaustafauglo (2011) highlights the basic SPS as: observing, classifying, measuring, and predicting. Karamaustafauglo further claims that; these skills provide the intellectual ground work in scientific inquiry such as ability to order and describe natural objects and events. In this study, the following were the science process skills that were considered, observation, classifying, measuring, predicting, inferences, communication and experimenting. These SPS were considered because the researcher believed that the laboratory work on reducing sugars imparted accurate observations, careful handling of apparatus and reagents during experimenting. Not only that, the researcher was for the view that learners developed the SPS to measure, to infer and finally arrive at the conclusion. Moreover, the practical test on reducing sugars when using the MSL kits involved learning by doing where the teacher mainly was the supervisor rendering individual help and guidance when required, this developed communication as well.

Harleen (1999), suggests that the development of ideas and understanding goes hand in hand with the development of SPS and attitudes. It is essential for students' future to be provided with SPS at educational institution because if these skills are not developed sufficiently, students cannot interpret the knowledge. With a similar view, Dennis *et.al* (2017) echoes that; the Intergration of SPS in teaching methods assist students to retrieve prior knowledge and anchor new incoming information in their cognitive framework. Therefore, the SPS that were development during the practical test on reducing sugars when using the MSL kits also enhanced the development of knowledge and stimulation

Tobin (1990) asserts that if the related evidence is not collected, collected concepts will not help students to understand what takes place. In this case, evidence on the practical test on reducing sugars was collected during experimenting where SPS which included observation, classifying, measuring, inferring, predicting and communication were developed. This helped learners to relate theory to practical thereby, understanding the concepts because knowledge and SPS develop simultaneously. However, Hudson (1998) argues that science education is not about teaching students to observe, classify, and measure and hypothesise per se. They can do that perfectly well, and have been doing so since long before they came to our science lessons.

A study conducted in Turkey by Karamaustafauglo (2011), propose that the experimenting skill was at the highest level of acquisition in student teachers among the integrated SPS and contrary to the results of (Hafez & Rashed, 2014), who indicated that a few Palestinian secondary school students selected the correct option for items related to the skill of experimenting while more of the students selected the correct option for the items related to the skill of observation, predicting and measuring. The findings from these two studies suggest that learners can develop the stated SPS during a practical test on reducing sugars when using the MSL kits.

Muzumara (2008), further highlights a number of competencies that should be displayed by science teachers which includes the designing, identifying, and implementing strategies aimed at developing scientific process skills. In line with Muzumara (2008), Machina (2012) adds that these skills enable students to collect data, engage in different scientific investigations and come up with evidence to help answer scientific questions problems. Aktamis and Ergin, (2008) also say that SPS are a necessary tool to produce and use scientific information, to perform scientific research and solve problems. Therefore, this indicates that, these SPS are vital in the future science career of learners and thus prompting the study to determine the SPS developed by learners during a practical test on reducing sugars when using the MSL kits.

Jones (2017), postulates that; ML programmes with their focus on hands-on inquiry-based instruction, will be effective at increasing students' knowledge and interest in STEM. Freedman (1997) investigated the impact of hands on science programme on attainment and attitudes reported that students (aged 14-15) who had regular laboratory instruction scored significantly higher ($p < .01$) on the objective examination of achievement in science knowledge than those who had no laboratory experience. Jonassen (1991), claims that knowledge is a function of how the individual creates meaning from his or her own experience. It refers to awareness of or familiarity with various objects, events, ideas, or ways of doing things. Further, Gottschalk (2007), adds that knowledge can only be stored in the human brain. It is what a knower knows, there is no knowledge without someone knowing it. Leach (1999), states that 'in order to appreciate how scientific knowledge is used, students need some rudimentary understanding of its ontology.'

Ontology (the branch of philosophy addressing the status of the entities in the material world) is in this context used to apprehend the relationships between the concrete objects used in the theories. These matters are, quite self-evident to teachers who are thinking about and seeing the experimental set ups as representations of scientific knowledge, but the situation is not so for most of the students. In a similar view Millar and Abrahams (2009; 2011) in their broad study found that a gross majority of talk in the classroom has to do with practicalities of the tasks, that is handling the objects (apparatus) and producing the phenomena and almost no time at all was devoted to discussing the ideas behind the phenomena. The focus on the classroom was on the 'hands on' side of the task, not on the 'minds on' side, leaving little time and attention for discussion about the ideas. Very little or no time at all for supporting the students' knowledge through discussion. Tiberghien (1999), opines that 'a practical task should not demand too many different cognitive activities at the same time because students only use a few at once. The minds-on approach combined with the practical activity should not overload the students' mind or otherwise none or very little real learning happens.

Therefore, the research focussed specifically on the practical food test on reducing sugars rather than all the food tests in order to establish the knowledge acquired by learners.

Additionally, Solomon (1999), talks about the importance of practical and theoretical learning supporting each other, they are intertwined and cannot be separated. A study conducted by Hofstein and Mamlock-Naaman (2017), revealed that, the way some science teachers teach science lessons encourage memorisation instead of sound investigative oriented learning and fails in affording students chances in planning inquiries and performing own experiments, manipulating materials and apparatus to enhance the construction of own knowledge of phenomena and related scientific concepts by students. Similarly, Jokiranta (2014), suggests that students should be prompted to handle the phenomena at hand on the conceptual level simultaneously to the practical activity, the activities and the exercises should be designed in a way that promotes making links between the practical and the theoretical. However, a study conducted by Rutto and Kptingel (2014), in Kenya indicates that students are less exposed to practical during science lessons.

The above aforementioned prompted the objective of the study to establish the knowledge acquired by learners during a practical test on reducing sugars when using the MSL kits.

MSL kits would change the attitudes of learners about science and it is a great career path if both teachers and learners are interested in using them. Lunetta *et.al* (2007) suggest that a well-planned and effectively implemented science education laboratory and stimulation experience stimulate students learning in varying levels of inquiry requiring students to be both mentally and physically engaged in ways that are not possible in other science education experiences.

In view of the above, ascertaining if stimulation is attained by learners during a practical test on reducing sugars when using the mobile science laboratory kits was necessitated.

Lord (1999), asserts that curiosity is the foundation of the scientific method, learners who ask questions make proper observations and can formulate hypotheses are the ones that will succeed in the field of science. Schreiner and Sjoberg (2004), seem to agree with Lord by suggesting that students at school experience this period of learning as interesting, joyful and stimulating in itself. A positive experience in school is more likely to make for lifelong learning and so for citizens' keen to learn more and keen to apply their learning. In support of this view, Nina *et.al* (2010) adds that, the performance of various hands-on activities influences students' interest differently positively and negatively.

Meanwhile, Abraham (2009), suggests that whilst practical work generates short term engagement it is relatively ineffective in generating motivation to study science or longer-term personal interest in the subject although often claimed to do so. Therefore, this study sought to ascertain if stimulation was attained by learners during a practical test on reducing sugars when using the MSL kits.

Most of the studies reviewed have acknowledged that the use of conventional science laboratories as well as the use of MSL in conducting practical lessons enhances the development of SPS, knowledge and stimulation. But has failed to provide answers to questions relating to the use of MSL kits when testing food for reducing sugars. It has also failed to give answers to the use of MSL kits in newly upgraded secondary school in Zambia.

2.4 Summary of the chapter

This chapter reviewed literature on the role of conventional and non-conventional science laboratories, in relation to development of science process skills, knowledge and stimulation by learners during practical science lessons. The literature reviewed suggests that the use of science laboratories enables learners to develop the appropriate SPS. Knowledge and stimulation. The chapter that follows presents the methodology of the study.

CHAPTER THREE: METHODOLOGY

3.1. Introduction

This chapter describes the methodology that was used in the study. The study is organised under the following sections: research design and approach, study site, target population, sample size, sampling technique, data collection instruments, validity, reliability, trustworthiness, data collection procedure, data analysis and ethical considerations.

3.2. Research Design and Approach

The research design used in this study was the concurrent triangulation design which is also known as convergent parallel design as it was the best for the study (Creswell, 2012). It formed the logic that linked the data that was collected and the conclusion that was to be drawn to the initial questions of the study in order to ensure coherence (Rowley, 2002).

The main reason of using this design in this study was because of its ability to enable the researcher to collect and analyse both qualitative and quantitative data concurrently and merge the results to interpret the findings on whether there was convergence, divergence or some combination (Creswell, 2009).

Using the concurrent triangulation design, the researcher was able to find out the extent to which appropriate science process skills, knowledge and stimulation were developed in learners during a practical test on reducing sugars when using the MSL kits. The researcher used the collected data to address all research objectives and questions. Figure 3.1 shows an illustration of how the concurrent triangulation design was applied

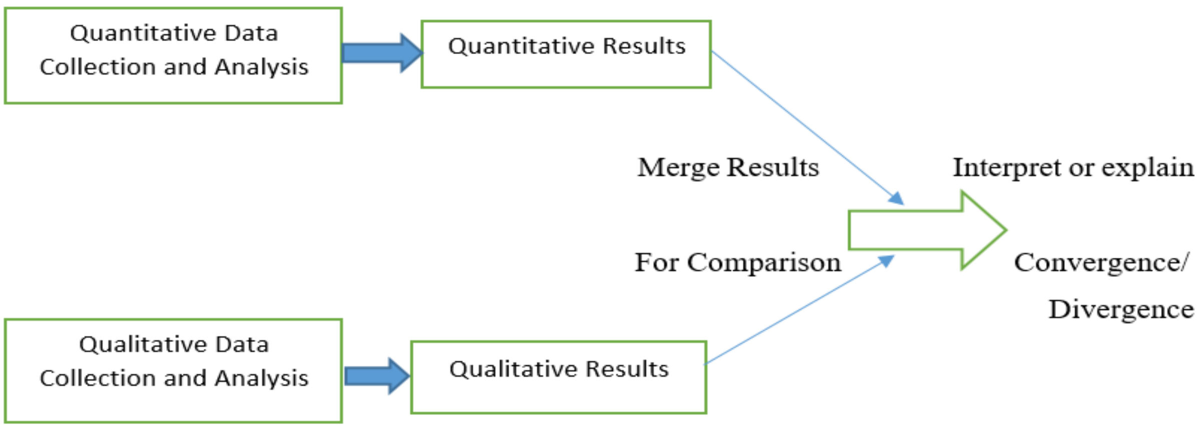

Figure 3.1: An illustration of how the concurrent triangulation design or convergent parallel design was applied
Source: Cresswell (2014).

Cresswell (2015) suggests that a mixed method research is an approach to research in the social, behavioural and health sciences in which the investigator gathers both quantitative (closed-ended) and qualitative (open-ended) data. In addition, Cresswell asserts that the two data are integrated, and then draws interpretations based on the combined strength of both sets of data to understand research problems. The researcher used the mixed method approach so as to mitigate limitations and biases found in both the qualitative and quantitative designs.

Triangulation using the three different instruments of data collection was a way of ensuring validity and credibility of the research findings. The design would establish the science process skills developed, knowledge acquired and stimulation attained by the learners during a practical test on reducing sugars while using Mobile Science Laboratory kits.

The research paradigm attached to this study is pragmatism. It sits comfortably alongside practical activity and routine situation as its focus is on concrete practices in the real world and its concern to develop theories that are recognised to those involved (Denscombe, 2003).

3.2 Study site

This study was conducted in Chinsali District of Muchinga province in four selected newly upgraded secondary schools. The reason for selecting these secondary schools was that the researcher was of the view that these schools are newly upgraded from primary schools to secondary schools. Besides, these were the beneficiary schools of the MSL kits and they were all government schools. The fact that the schools were far apart, they formed a wider representation of Chinsali as each school was assumed to be a separate entity.

3.3 Target population

The population of this study was a total of 315 respondents. This study targeted the only four (4) schools in Chinsali District that had received MSL kits and were upgraded from primary to secondary schools. Therefore, the target population comprised all Heads of Departments of natural sciences (4), all teachers of biology (11), all grade 11 learners (150) and all grade 12 learners (150). The population conformed to the above mentioned criteria to which the study intended to generalise its results (Bryman, 2001). In addition, the researcher hoped that these schools would have covered the necessary content and conducted some practicals on food tests using the MSL kits.

3.4 Sampling Techniques

This study used both purposive and stratified random sampling. Purposive sampling was used to select the heads of departments and teachers of biology. In purposive sampling, the researcher decides on what needs to be known and targets people who can and are willing to provide the information by virtue of their knowledge or experience (Cohen et al., 2007) Schools were purposively sampled by virtue of being government and in possession of MSL kits.

Since the learners were from grade 11 and 12, a stratified random sampling was used to come up with two strata, grade 11 and grade 12. The grades of learners were written on small pieces of papers and stored in one box. The grades were raffled and the selection was done at random until the required number was attained. This ensured balance and thus minimised biasness.

3.5 Sample size

Purposive sampling was used in selecting the respondents. The sample size was determined to be 176 using Yamane (1967). Yamane (2015) devised a formula of determining a sample size of the population for a study. The formula below by Yamane was used to determine the sample size for this study.

$$n = \frac{N}{1 + N(e)^2}$$

n = sample size,

N = population size i.e. 315

e = error margin (0.05) at 95% confidence interval

n was = 176.223 which is 176 when rounded off.

The sample size was large enough to serve as an adequate representation of the population which the researcher wishes to generalise and small enough to be selected economically in terms of subject availability and expense in both time and money (Best & Khan, 2006). Best and Khan have argued that an ideal sample size may depend on the nature of the population and the type of data that needs to be collected and analysed. It is for this reason that every researcher needs to come up with a good and manageable sample representation of the population.

3.6 Sources of data and research instruments

Both primary and secondary data were of use to the research.

Primary Sources

According to Fensham (2015), primary sources are defined as any sources of information that were created at the time of study. They are also deemed as original sources. Thus in this regard, questionnaires, observation schedules and interview guides were the primary sources of the data.

The questionnaires were self-developed and were organised in 3 sections. The first section had statements that identified the science process skills developed during a practical test on reducing sugars when using the MSL kits. The second section had statements that established the knowledge acquired while the third section had statements that indicated how the learners were stimulated during a practical test on reducing sugars when using the MSL kits. The statements were measured on a 5-point likert scale. The respondents were expected to rate themselves on how much they agreed with each statement from strongly agree (1), agree (2), not sure (3), disagree (4), and strongly disagree (5).

The researcher used the mixed approach with a view that it has a higher degree of validity because of its flexibility in data collection through the method of triangulation (Ghosh, 1992). This enabled the researcher to have confidence that concurrent triangulation design would yield good results for the study.

Observations were considered to be an important research instrument in this study because of the view that it is a more natural way of collecting data. Furthermore, data collected through observation is more real and true (Sidhu, 2014). The reason could be because it depicts what exactly takes place on the actual ground than data collected from other methods. An observation is a method in which the researcher takes field notes on the behaviour and activities of individuals at the research site (Creswell, 2003).

Observations were conducted in this study where the researcher was an onlooker focusing only on specific behaviour patterns reflecting on a pre-defined observation schedule. The observation schedule was also organised in 3 sections in line with the research questions. The first section had science process skills outlined with statements measured on a 5-point likert scale. Section B had statements on the appropriate knowledge acquired and the last section had statements on stimulation. A 5-point likert scale ranged from strongly agree, agree, not sure. Disagree, strongly disagree. The researcher made 14 lesson observations using the lesson observation guide to rate the learners on the developed appropriate SPS, knowledge and stimulation when using the MSL kits. So, the researcher conducted the lesson observations. Details of this instrument are in Appendix C

Secondary Sources

Secondary sources are those created by someone who did not experience first-hand or participated in the events or conditions. They are the prewritten materials from previous researches, publications, books and journals (Fensham, 2015).

3.7. Data Collection Procedure

In order to validate the findings in this study, the researcher recorded some of the interviews where respondents permitted her to record during data collection so as to check for unclear information and then member check with the respondents. During member checking, the researcher had to make use of the responses for the verification of the findings and was able to make follow ups on issues that needed clarity. In addition, the researcher was able to compare the findings from the interviews, observation schedules and questionnaires in order to check whether the analysed data represented the phenomenon under study.

Piloting enabled the researcher to make amendments on the research instruments which led her to collect appropriate data from the sampled results.

To ensure reliability, thirty (30) questionnaires for grade 11s and 12s from the schools that were not under study in Chinsali District were piloted.

Blair and Czaja, (2014) asserted that if the questionnaire is not well developed, it tends to have a high probability of making the researcher collect inaccurate data. This would paralyse the whole essence of the research to be carried out. It was in this view that questionnaires were pre-tested and assessed and were found that:

i. The statements contained in the questionnaire measured what they were supposed to measure.
ii. The statements provoked a response.
iii. The statements were not researcher biased.
iv. The wording was clear and different respondents interpreted the statements in the similar way.

This enabled the researcher to believe that the questionnaires were clear and specific.

Trustworthiness in this study was achieved through giving a clear and distinctive description of the: research context, selection and characteristics of respondents, data collection as well as the procedure for data analysis.

Further, in order to get the first-hand information about the learners developed appropriate science process skills, knowledge and stimulation when using the MSL kits during a practical test on reducing sugars, the researcher asked for permission from the school administration in the selected schools in Chinsali district to observe some biology practical lessons on food tests, 14 biology practical lessons were observed by the researcher. This was done so as to compare the responses in the questionnaires to the actual classroom practices during a practical test on reducing sugars while using the MSL kits.

3.8. Data Analysis

Quantitative data was analysed with the use of Statistical Package for Social Sciences (SPSS) version 20 while qualitative data was analysed using content analysis. The researcher used a mixed methods approach because collection and analysis of data involved both quantitative and qualitative approaches (Cresswell 2014). Having adopted a mixed approach, and a concurrent triangulation design to collect and analyse data. The researcher collected both forms of data at the same time during the study and then integrated the information, the researcher then converged quantitative data from the questionnaires and qualitative data from the observations and the interviews in order to provide a comprehensive analysis.

Miles and Huberman (1994) documented that data analysis in the qualitative model comprises three levels of activities which are: data reduction, data display and conclusion drawing or verification. Slightly different from the views of Miles and Huberman, Sjostrom and Dahlgren (2002) in their study revealed that qualitative analysis involves seven key steps which are: familiarisation, compilation of answers from respondents, condensation or reduction, preliminary comparison or classification, naming of categories and contrastive comparison of categories.

The first step was familiarisation, the researcher read through all the collected data in order to understand and make corrections. Where necessary, the researcher went back to the actual respondents or recorded data for corrections. After familiarisation, the researcher compiled responses from all the participants where vital responses were to be considered. Thereafter, the researcher reduced the participants' responses by finding the central parts of the dialogue and classified responses that sounded similar. This was followed by preliminary comparison and finally naming of categories or coding (Cresswell, 2009). The next step was contrastive comparison of categories where the description of the character of each category and similarities between categories were done. The purpose of this step was to come up with similar emerging themes (Sjostrom & Dahlgren, 2002). Thus qualitative data collected from interviews were analysed from the seven steps cited above and coded into emergent themes (Creswell, 2009).

The researcher used thematic content analysis in analysing qualitative data to have the research questions answered thereby, creating themes using the grounded theory.

Quantitative data obtained from both the questionnaires and observation schedule were analysed using the statistical package for social sciences (SPSS) software version 20 to generate descriptive data and test for significance differences by way of independent t-test and the one way Analysis Of Variance (ANOVA).All statistical tests were evaluated at 95% confidence interval. The researcher specifically used averages, means, independent t-tests and one way ANOVA.

Having collected data on only one occasion but from different sets of people prompted the researcher to use the independent t- test. Furthermore, the researcher wanted to establish whether there was a statistically significant difference in the mean scores of the groups. One-way ANOVA was used because the groups were diversy in nature and wished to determine whether there was a significant difference in the mean scores on the dependent variable between and within the groups (Pallant, 2007.

The quantitative results were compared and converged with qualitative results before a conclusion was drawn. It was through this analysis of data where a fairly well informed exploration about the developed appropriate SPS, knowledge and stimulation during a practical test on reducing sugars when using the MSL kits in selected schools in Chinsali District of Muchinga Province was realised.

3.9 Ethical considerations

In order to have data collected, the researcher requested for permission from the Provincial Education Officer (P.E.O) of Muchinga province and the District Education Board Secretary (DEBS) for Chinsali district. This was done in order for the researcher to be given permission to freely interact with the selected respondents without any interference. The researcher also had to ask for consent from the respondents to enable them make an informed decision on whether they could participate in the study or not. Since respondents comprised grade 11s and grade 12s, the order of administering the research instruments was guided by the sampling techniques described in Section 3.6.

3.10. Summary of the chapter

What has been discussed in Chapter three is the methodology that was used in the study. Mixed methods design was used particularly the concurrent triangulation design which is also known as the convergent parallel design. This design enabled the researcher to collect and analyse both the qualitative and quantitative data, merge the results for comparison and eventually interpret. Besides, the researcher also discussed the: study site, target population, sample size which was 179 participants, sampling techniques (i.e. both purposive and simple random sampling), data collection instruments, validity and reliability, data collection procedure, data analysis as well as ethical considerations. The next chapter presents the findings of the study

CHAPTER FOUR: PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents the analysis of the primary data collected and its interpretation. The analysis is in three parts including their implications. The first part presents the analysis on the appropriate SPS developed by the learners during a practical test on reducing sugars when using the MSL kits. The second presents the analysis of the appropriate knowledge acquired by learners in a practical test on reducing sugars when using the MSL kits. The third presents the analysis of the stimulation attained by learners during a practical test on reducing sugars when using the MSL kits. The chapter ends with a summary of all the findings.

4.2 Demographics

The learners were 166 (67 grade 11s and 99 grade 12s), Heads of Departments of Natural Sciences were 4 (all males) and teachers of biology were 9 (3 females and 6 males). Of the 166 learners 55 were females and 111 were males. Figure 4.1 illustrates the learner's age group.

4.2.1 Learner's age distribution

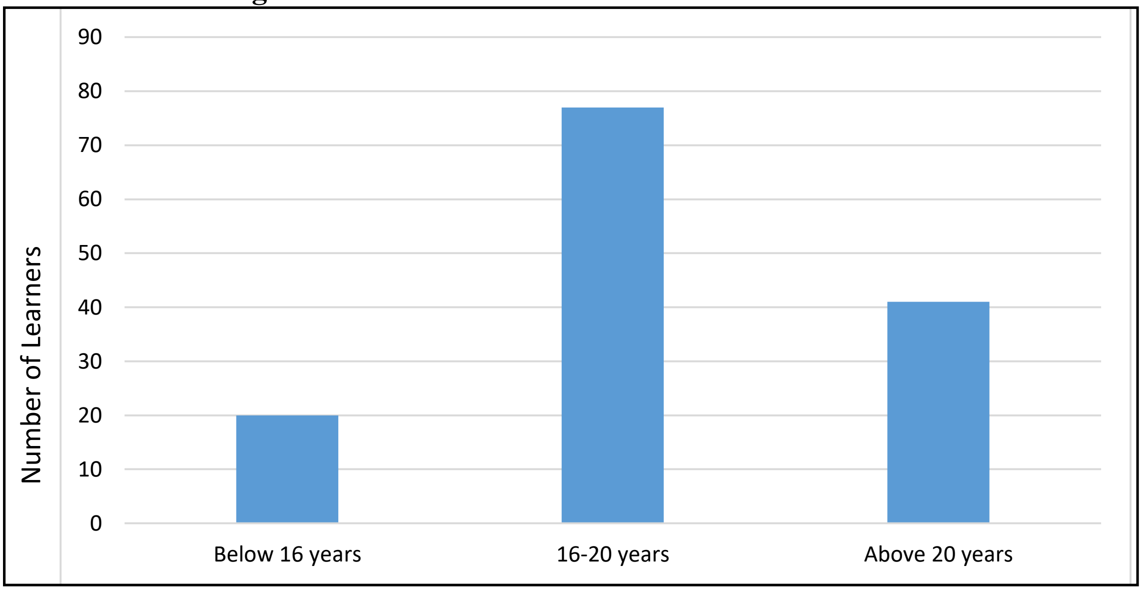

Figure 4.1 Age of learners.
Source: Field data (2018)

From the 166 learner respondents, those who were 16-20 years were 49 and constituted the majority.

4.3 Research Question one

Research Question 1 was "What are the appropriate SPS developed by learners in a practical test on reducing sugars when using MSL kits?"

In order to answer Research Questions 1, the learners and teachers were given questionnaires to rate the development of the SPS. Observations were conducted by the researcher about the practical test on reducing sugars while using the MSL kits using the observation schedule. Interviews were also conducted on a few learners and teachers using the interview guide in order to ascertain the development of the appropriate SPS.

Appendix H present the ratings by learners on the developed SPS. It illustrates the frequency and percentage ratings. It shows that on average 52% of the respondents strongly agreed to the aforementioned assertions, 33 % agreed that they had developed the SPS. The percentage of the respondents that, indicates that they were not sure whether they had developed the SPS or not were 11%. On the other hand, 3 % of the respondents disagreed and 1% of the learners strongly disagreed that they had developed the SPS. This suggested that most of the learners had developed the appropriate SPS when using the MSL kits to test food for reducing sugar.

Appendix I shows the ratings of the teachers on the learners developed SPS. It illustrates the frequency and percentage ratings. It shows that on average 58 % of the teacher respondents strongly agreed and 35 % of the respondents agreed that learners developed the SPS. Meanwhile, 7% of the teachers were not sure if learners had developed the SPS or not and none of the teachers disagreed or strongly disagreed that learners did not developed the SPS science process skills. This implied that many teachers claimed that SPS were developed by learners during a practical test on reducing sugars when using the MSL kits.

Appendix J illustrates the frequency and percentage ratings from the observation schedule. It shows that on average the researcher strongly agreed that learners had developed the SPS. This is also evidenced in Appendix E where learners were conducting the practical test on reducing sugars using the MSL kits. This implied that researcher observed that some SPS were developed by learners during the practical test on reducing sugars when using the MSL kits. Section 4.3 presents the findings from the interviews about the developed SPS.

4.4 Findings from interviews

4.4.1 SPS developed by learners during the practical test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Question 1 of Appendix D. A question which sought to bring out the SPS that learners had developed during the practical test on reducing sugars when using the MSL kits. Out of the 61learners who were interviewed 50 indicated that they had developed the experimenting skill with 33 out of 61 having developed the measuring skill. While 40 strongly indicated to have had developed the observation skill. On the other hand 25 out of 61 learners indicated to have had developed the inference skill. And 23 out of 61 learners had developed predicting skill. This is what some of the respondents had to say;

PP 48;

> *…We first identified the solution given, we added the reagent which is benedict to the sample solution then heated the mixture for 5 minutes and see how the colours changed. The colours changed from blue to yellow to orange and finally a red precipitate. Then we concluded that reducing sugars were present. If reducing sugars are absent the colour remains the same…If the food sample was in solid form first crush and add water and shake very well then add the reagent. Before adding the reagent separate using the funnel by filtration. Collect the filtrate and add benedict solution and observe the colour changes.'*

In a separate interview PP 56 had this addition;

> *…get benedict solution and put in a hot water bath and observed the colour changes from blue to green to yellow to*

orange… brick red did not appear ,they were just 3 colours because reducing sugars were less…we added equal volumes of sample solution to reagent. If food sample is in solid form then crush and add water and separate using a filter paper, the filtrate is the solution used to test for reducing sugars by heating using a Bunsen burner too much benedict solution…changes to black.

In another interview PP 44 with the similar view said:

…Got the powder and onion as specimen, crushed the onion ,added the crushed onion to water…filtered the mixture to separate the onion from the liquid…collected the filtrate which is the onion liquid then using a measuring cylinder added $2cm^3$ *of benedict solution and heated in a hot water bath. The colour changed from blue and changed to green.*

In addition, PP 2 had this to say;

... the food sample should at times be solid, powder or liquid... Given a solid like orange, cut and extract the juice…we got the onion and crushed then got the liquid. Then filter and collect the liquid then add the benedict solution. The volume of the benedict solution should be equal to the food sample solution. Then heat.

PP 4 also added this:

…got the given solid food sample and crushed to break from larger particles to smaller particles , crushed sample was added to the liquid then filtered ... collected the filtrate and added benedict solution then heated using a hot water bath and observed the colour changes from yellow to green and orange

And this is what PP 24 said;

...Solid should be crushed, use a duster to break and add a little water and use a filter to separate…collect the filtrate in

a test tube and add an equal amount of benedict solution then heat using a hot water bath.

The responses from learners as participants 48, 56, 44, 2, 4 and 24 suggested that SPS for experimenting, observation, measuring and inference were developed during the practical test on reducing sugars when using the MSL kits. However, a number of other learners had this to say;

PP 13 narrated:

> *... there are many colours blue, black and yellow…reducing sugars is brownish when you get iodine solution ,get a test tube and put hydro solution, boil the water and put the test tube on the pot…the volume of benedict solution is 2cm^3…*

In addition, PP 40 said:

> *…used onion and was crushed and put in the test tube and mix with distilled water…got distilled water and added the powder then see the colour changes… added perpendicular solution which is blue colour …the colour remains the same … Colour change to yellow blue and reddish*

Furthermore, PP 53 said:

> *…added equal volume of benedict solution to the food sample and heat using a hot water bath…if reducing sugars are present the colour changes from blue to black to green …I'm very sure it turns from black to green to reddish brick …then conclude that reducing sugars are present …if reducing sugars are absent it only changes to black.*

In a separate interview PP 7 said:

> *…Get a beaker and put water and get test tube then put the chemical in the beaker on the fire…the colour changes if you add the …the chemical with colour blue, the colour change to … shani…. Madam, red brick.*

PP 6 had this similar view:

> *…we used benedict solution to test for non-reducing sugars… measured an equal volume and added to the food sample …the colour changed to yellow which means reducing sugars were present…the quantity of food sample should be 2-3 drops …sample solution should always be 3 drops…it was a mistake to say they should be equal.*

The responses given by learners as participant 13, 40, 53, 7 and 6 indicated that these learners were not sure with the experimental procedure and did not even know the reagent to use. So, these responses suggested that none of the SPS were developed by these learners.

4.4.2 Communication as a SPS developed during the practical test on reducing sugar when using the MSL kits.

The responses to Question 1 did not indicate whether communication SPS was developed by the learners and this prompted the researcher to ask a probing question pertaining to communication. Out of the 61 learners 32 strongly indicated to have had developed the communication skills, and this is what some of them had to say.

i. *Yes we were able to communicate where we were not clear, we were asking the teacher to direct us where we were not sure.*
ii. *…wanted to know more so I was able to discuss with my friends in the group*
iii. *yes… about how to measure the chemical we put in benedict solution*
iv. *… we were communicating*
v. *we were communicating on method*
vi. *we were communicating by way of listening to my friends opinion*
vii. *…followed instruction*
viii. *…communication was done and I can be able to explain to my friends because we were discussing*

On the contrary, responses from some learners suggested that they had not developed the SPS for communication as summarised below.

i. *communication when benediction solution was added it turns to yellow, blue and orange*
ii. *Yes about how to measure the chemical we put in benedict solution.*
iii. *no communication*

4.4.3 Classifying as a SPS developed during the practical test on reducing sugar when using the MSL kits

The responses to Question 1 did not indicate whether SPS to classify was developed by the learners and this prompted the researcher to further ask a probing question on different classes of carbohydrates and the difference between reducing and non-reducing sugars in order to ascertain if the SPS to classify was developed. Out of the 61 learners only 20 indicated to have had developed the skill to classify and here is what some of them had to say;

i. *Difference between RS and non RS colour changes with*

   RS… with non RS no change it was just the colour of the chemical reagent.

ii. *Classes of carbohydrates are monosaccharides and disaccharides*

iii. *… RS is polysaccharide and is a body unit of saccharides and non RS are polysaccharides. Classes of carbohydrates is onion.*

The views of the learners suggested that many of them developed the appropriate SPS during the practical test on reducing sugars when using the MSL kits. Figure 4.2 shows the developed SPS by learners during a practical test on reducing sugars when using the MSL kits

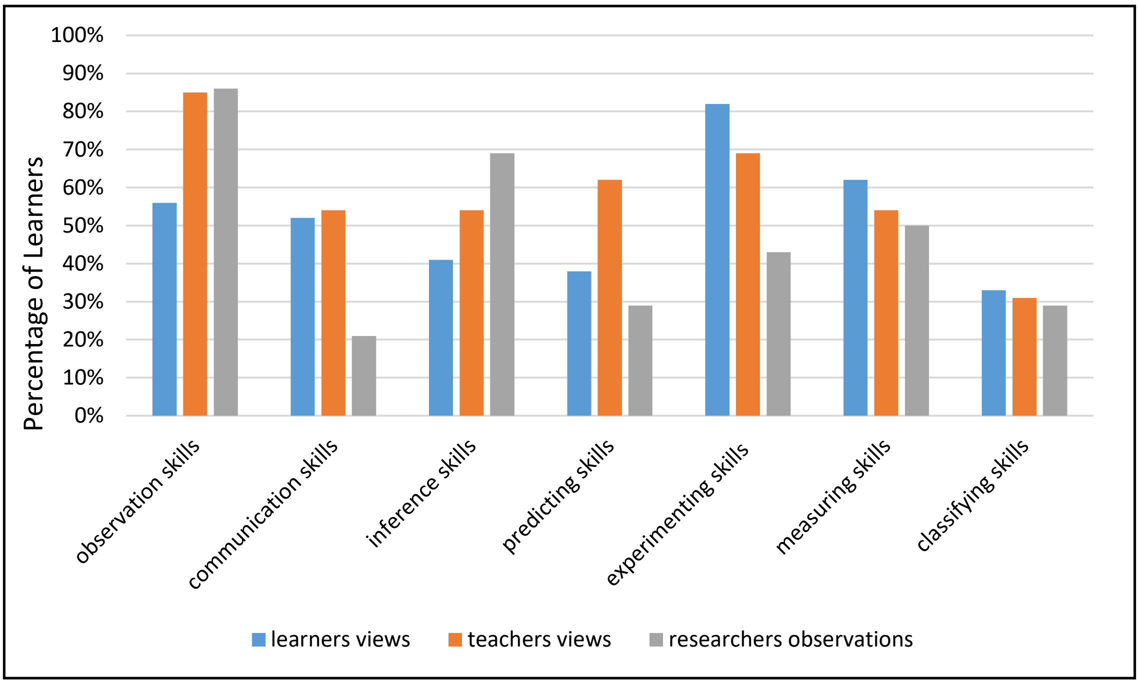

Figure 4.2: Developed SPS by learners during a practical test on reducing sugars when using the MSL kits

Source: Field data (2018)

Figure 4.2 shows that out of the 61 learners who were interviewed 50 indicated that they had developed the experimenting skill representing 82%. Out of 61, a total of 40 learners claimed to have had developed the measuring skill representing 66%. While 33 indicated to have had developed the observation skill representing 54%, Another 32 out of the 61 learners strongly developed the communication skills representing 54% as well. On the other hand 25 out of 61 learners indicated to have had developed the inference skill representing 41%. And 23 out of 61 learners had developed predicting skill representing 38%. While only 20 out of 61 learners developed the skill to classify representing 33%.

In addition, Figure 4.2 shows that 12 out of the 14 observations made by the researcher had indicated that learners developed the observation skill representing 86% with 9 out of 14 indicating that learners had developed the inference skill representing 64%. While 7 out of 14 suggested that learners had developed the measuring skill representing 50%. The other 6 out of 14 indicated that learners had developed the experimenting skill representing 43%. And 4 out of the 14 observations indicated that learners had developed the skill to predict and classify representing 29% only 3 observations indicated that the skill to communicate representing 21% had been developed in learners.

Furthermore, Figure 4.2 shows that 11 out of the 13 (4 HODs and 9 teachers) teachers interviewed indicated that learners had developed the observation skill representing 85%, and 9 out of 13 representing 69% indicated that learners had developed the experimenting skill. Then, 8 out of the 13 teachers indicated that learners had developed the predicting skill representing 62%. Meanwhile, 7 out of the 13 teachers indicated that learners had developed the measuring, communication and inference SPS representing 54%. And only 4 out of the 13 teachers indicated that learners had developed the skill to classify representing 31%.

The description in Figure 4.2 suggested that the views of both the learners and the teachers and the observations as evidenced in Appendix E indicated that learners had developed more in the experimenting, observation, measuring and communication while the classifying SPS did not seem to have had developed more during the practical test on reducing sugars when using the MSL kits. Section 4.4 are presentations of findings from the t-test and the ANOVA about the developed SPS.

4.5 Presentation of findings from the independent t-test and One-way Analysis of Variance summary (ANOVA)

A Comparison of learners and teachers responses on the developed SPS by learners during the practical test on reducing sugars when using the MSL kits indicated that $t = 1.30$, degrees of freedom (df) = 177, and $p = 0.03$. In this case t was statistically significant. So, based on examining the means, learners had a higher score (32.39 ± 9.97 on the acquisition of SPS than teachers (28.77 ± 8.08).

A Comparison within a group of learners (males and females) on the responses about the developed SPS during the practical test on reducing sugars when using the MSL kits indicated that $t = 0.145$, degrees of freedom (df) = 164, and $p = 0.01$ in this case t was statistically significant.so, based on examining the means, male learners had a higher score (32.11±9.73) on the development of SPS than female learners (31.90 ±7.63).

A Comparison within a group of teachers (males and females) on the responses about the developed SPS by learners during the practical test on reducing sugars when using the MSL kits indicated that $t = 0.58$, df = 11, and $p = 0.01$ in this case t was statistically significant.so, based on examining the means, male teachers had a higher score (29.50 ± 8.99) on the development of SPS by learners than female teachers (26.33 ± 4.16).

A Comparison of Means and standard deviation by schools on the developed SPS by learners during the practical test on reducing sugars when using the MSL kits indicated no significant difference SSI (31.94 ± 9.35), SS2 (30.00 ±11.20), SS3 (33.47 ± 8.40), SS4 (35.75 ± 8.87). The one-way ANOVA also indicated no significant difference in the development of SPS by learners among schools (df = 3; F (3,162) = 2.41, P = .069)**.**

A Comparison of Means and standard deviation of responses by learners on the developed SPS during the practical test on reducing sugars when using the MSL kits indicated no significant difference in the development of SPS due to age.
The findings from the one-way ANOVA also indicated no significant difference df= 3, F (2,163) = .523, P=. 594. There was no significant difference in the development of SPS by learners due to grades (df =1; F = 2.44, P= .120) and due to gender df = 1, F (1,164) = .087, P=. 769, even due to schools, df= 3, F (3, 10) =.258, P= 0.854.

4.6 Research Question two

Research Question 2 was "What is the appropriate knowledge developed by learners in a practical test on reducing sugars when using the MSL kits?"

In order to answer Research Questions 2 learners and teachers were given questionnaires to rate the acquisition of the appropriate knowledge. Observations were conducted by the researcher on the practical test on reducing sugar while using the MSL kits using the observation schedule. Interviews were also conducted on some learners and teachers using the interview guide in order to ascertain the developed knowledge.

Appendix K presents the ratings by learners on the development of the appropriate knowledge. It illustrates the frequency and percentage ratings. It shows that on average 48 % of the learners strongly agreed to the statements and 35 % agreed. This implied that most of the learners indicated that they had developed the appropriate knowledge. Meanwhile, 13 % of the learners were not sure if they had developed the appropriate knowledge or not. While 3% disagreed 1% of the learners strongly disagreed that they had developed the appropriate knowledge.

This implied that learners had developed the appropriate knowledge during a practical test on reducing sugars by the use of the MSL kits.

Appendix M presents the ratings from the observation by the researcher on the development of the appropriate knowledge. It illustrates the frequency and percentage ratings. It shows that on average the researcher strongly agreed that learners had developed the appropriate knowledge. This implied that the appropriate knowledge was developed by learners during practical test on reducing sugars by the use of the MSL kits. Section 4.5.1 presents findings from the interviews on the development of the appropriate knowledge by learners during the practical test on reducing sugars when using the MSL kits.

4.6.1 Appropriate knowledge acquired by learners to differentiate reducing sugars from non-reducing sugars during the practical test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Question (ii) of Appendix D. A question which sought to bring out the appropriate knowledge that learners had developed on the difference between reducing sugars and non-reducing sugars during the practical test on reducing sugars when using the MSL kits.

Of the 61 learners who were interviewed, only 30% had indicated to have had developed the knowledge to differentiate reducing sugars from non-reducing sugars during the practical test on reducing sugars when using the MSL kits. Many of them indicated to have had not developed the appropriate knowledge and this is what some of them had to say;

PP4 lamented:

> *…the difference between reducing sugars (RS) and non reducingsugars is that for non RS we used hydrochloric acid and for RS we did not use hydrochloric acid.*

In a separate interview PP5 said:

> *…The difference between RS and non RS is that of the procedure… And the reagents used …sodium hydroxide and hydrochloric acid …the colour changes remained the same from blue to brick red.*

PP7 and PP44 had this to say:

…I don't know the difference between RS and non RS…

In addition, PP28 echoed:

…RS is sucrose because they are bitter and non RS are fructose…

PP26 had this view:

…RS is a process whereby if you do some solution the colour changes and for non RS there is no colour change...

4.6.2 Appropriate knowledge acquired by learners to describe and explain the procedure involved during the food test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Question (iii) of Appendix D. A question which sought to bring out the appropriate knowledge that learners had developed to describe and explain the procedure involved during the food test on reducing sugars when using the MSL kits.

Of the 61 learners who were interviewed, about 72% of learners indicated to have had developed the appropriate knowledge to describe and explain the procedure involved during the food test on RS when using the MSL kits. This is what some of them had to say;

PP7 narrated:

… Get a beaker and put water and get a test tube….then put the chemical in the beaker on the fire…there was a clamp stand and observe the colour changes…

With a similar view PP9 said:

…For RS use benedict solution and for non RS use hydrochloric acid…changes come after benedict solution was added. The quantity of benedict solution was $2cm^3$ to $2cm^3$ of food sample…if food sample is in solid form e.g. lemon and tomato, cut into small pieces and put in a clean

test tube and add 2cm^3 of water then shake… To get the solution you tear the tomato…get the solution and putting a clean test tube and warm to observe the colour changes…hold the test tube when heating using a test tube holder…the practical test on RS is dangerous because we used hot water…

PP19 had this narration:

… Get the food sample and put in the pot and observe the colour changes. Add benedict solution to observe the colour changes…measure 3 drops of benedict solution should be equal to food sample…boiling is done on fire…

PP21 narrated that:

…if food sample is in solid form crush it…if you get it like that it won't give out the colour changes i.e. correct result…you crush using the mortar and pestle …to separate the mixture i.e. solid from liquid. Put food sample in the liquid and wait for a while so that it leaves some nutrients there and then filter using a filter funnel use filtration method or decantation…use benedict solution and the volume should be 2cm^3 -3cm^3…two much of benedict solution will make the results wrong, the colour change directly to brick red without changing in stages…too little won't change maybe blue to green only…

PP 21 further observed that:

…Test for reducing sugars is more dangerous because it involves fire for heating the food sample and if not using well can be burnt or the hot water can burn you if not careful…

4.6.3 Appropriate knowledge developed by learners to discuss and explain the measure of the required volume of the reagent and the food sample during the food test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Question (iii) of Appendix D. A question which also sought to bring out the appropriate knowledge developed by learners to discuss and explain the measure of the required volume of the reagent and the food sample during the food test on reducing sugars when using the MSL kits.

Many learners representing 68% indicated to have had developed the appropriate knowledge to discuss and explain the measure of the required volume of the reagent and food sample during the food test on reducing sugars when using the MSL kits. This is what some of them had to say;

PP 22 had this view:

> *… Add 2 cm^3 of benedict solution to the food sample…much benedict solution makes the colour change fast and too little makes no change …*

PP 25 echoed:

> *… We were told to get the same quantity of benedict solution as the food sample…2cm^3 of the sample add 2cm^3 of benedict solution …*

PP 20 narrated:

> *…we use benedict solution to test for RS …The volume should be 2cm^3 and should be equal … too much benedict solution when added it turns orange and…too little benedict solution it will be yellowish …*

PP 21had this to say:

> *….the volume of benedict solution should be 2-3cm^3…*

PP 23 added:

... the measurement should be equal ... 2cm^3 -2cm^3 of sample solution to chemical reagent ...

PP 46 had the following to say:

... The measurement should not always be 2cm^3, it depends on the volume of the sample solution...

4.6.4 Appropriate knowledge developed by learners to describe the colour changes during the food test on RS when using the MSL kits

Having interviewed the learners in reference to Question (iv) of Appendix D. A question which sought to bring out the appropriate knowledge developed by learners to describe the colour changes during the food test on RS when using the MSL kits.

Learners representing 69% indicated that they had developed the appropriate knowledge to describe the colour changes during the food test on RS when using the MSL kits. This is what some of them had to say;

PP 44 narrated:

... The colour changed from blue and changed to green...

In a separate interview PP 56 lamented:

...the colour changes from blue to green to yellow to orange... brick red did not appear, they were just 3 colours because reducing sugars were less ... too much benedict solution ...changes to black ...

PP 4 added:

... and observed the colour changes from yellow to green and orange...

PP 48 had this to say:

... The colours changed from blue to yellow to orange and finally a red precipitate...

In addition PP 54 said:

... the colour of the food sample and benedict solution changes from blue to green to yellow to orange and finally brick red,

PP # 28 had this to say:

> *…the colour changed from blue to green to yellow to orange and finally brick red …*

4.6.5 Appropriate knowledge developed by learners to rank the proceedings of the food test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Questions (i) and (iii) of Appendix D. The questions that sought to bring out the appropriate knowledge developed by learners to rank the proceedings of the food test on reducing sugars when using the MSL kits.

Learners representing 74% indicated that they had developed the appropriate knowledge to rank the proceedings of the food test on reducing sugars when using the MSL kits. This is what some of them had to say;

PP 24 had this view:

> *…crush the solid food sample and add a little distilled water…use a filter paper separate .Collect the filtrate in a test tube and add an equal amount of benedict solution then heat using a hot water bath …*

PP 24 further added:

> *…using the Bunsen burner or spirit burner makes the practical for RS dangerous… and heating should not be done directly because spirit and gas is highly inflammable…if there is negligence a fire can break out easily." see appendix.*

PP 9 suggested:

> *…if food sample is in solid form put in a mortar and crush using a pestle, add water then filter using the filter funnel to get food sample in liquid form and heat…*

PP12 had this narration:

> *…food sample in solid form first crush then filter to obtain a liquid…if in powder form just add water …and if in liquid form add the reagent then heat...*

4.6.6 Appropriate knowledge developed by learners to make conclusions from the observations during the practical food test on reducing sugars when using the MSL kits

Having interviewed the learners in reference to Questions (iv) on Appendix D. A question which sought to bring out the appropriate knowledge developed by learners to make conclusions from the observations during the practical food test on reducing sugars when using the MSL kits.

About 65% learners indicated that they had developed the appropriate knowledge to make conclusions from the observations during the practical food test on reducing sugars when using the MSL kits. This is what some of them had to say;

PP 24 lamented:

> *… If the colour changes from blue to green to yellow and to orange or brick red …Then you conclude that reducing sugars are present. And if the colour remains the same colour as benedict solution then reducing sugars are absent …*

PP 6 added:

> *…colour changes to yellow which means that reducing sugars were present.*

PP 9 also said:

> *…colours changed from it was looking blue and changed to brick red to confirm the presence of reducing sugars.*

Many respondents had views similar to PP24, PP6 and PP9 implying that many learners had developed the appropriate knowledge. Figure 4.3 shows the appropriate knowledge developed by learners during the practical test on reducing sugars when using the MSL kits.

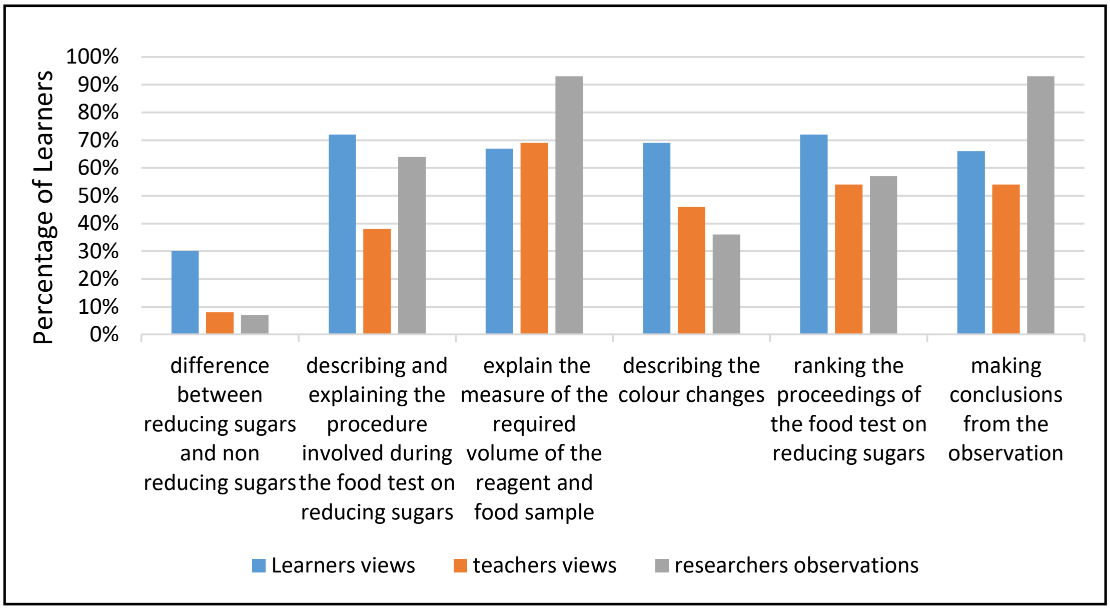

Figure 4.3: The appropriate knowledge developed by learners during a practical test on reducing sugars when using the MSL kits

Source: Field data (2018)

Figure 4.3 shows that many learners developed the appropriate knowledge during a practical test on reducing sugars when using the MSL kits. Out of the 61 learners interviewed, only 30% had developed the knowledge to differentiate reducing sugars from non-reducing sugars. However, 72% indicated to have had developed the appropriate knowledge to describe and explain the procedure involved during the food test on reducing sugars and 68% indicated to have had developed the appropriate knowledge to discuss and explain the measure of the required volume of the reagent and food sample during the food test on reducing sugars. Meanwhile, 69% indicated that they had developed the appropriate knowledge to describe the colour changes during the food test on reducing sugars and 74% indicated that they had developed the appropriate knowledge to rank the proceedings of the food test on reducing sugars while 65% indicated that they had developed the appropriate knowledge to make conclusions from the observations during the practical food test on reducing sugars.

The views of the teachers that were interviewed suggested that, less than 10% of the learners indicated to have had developed the knowledge to differentiate reducing sugars from non-reducing sugars. And only, 38% were indicated to have had developed the appropriate knowledge to describe and explain the procedure involved during the food test on reducing sugars and 69% were indicated to have had developed the appropriate knowledge to discuss and explain the measure of the required volume of the reagent and food sample during the food test on reducing sugars. Meanwhile, 48% were indicated that they had developed the appropriate knowledge to describe the colour changes during the food test on reducing sugars and 54% were indicated that they had developed the appropriate knowledge to rank the proceedings of the food test on reducing sugars while 55% were indicated to have had developed the appropriate knowledge to make conclusions from the observations during the practical food test on reducing sugars.

From the observations it was evident that some appropriate knowledge were developed by the learners. It was observed that, less than 10% of the learners indicated to have had developed the knowledge to differentiate reducing sugars from non-reducing sugars. And, 64% indicated to have had developed the appropriate knowledge to describe and explain the procedure involved during the food test on reducing sugars and 92% indicated to have had developed the appropriate knowledge to discuss and explain the measure of the required volume of the reagent and food sample during the food test on reducing sugars. Meanwhile, 36% indicated that they had acquired the appropriate knowledge to describe the colour changes during the food test on reducing sugars and 58% indicated that they had acquired the appropriate knowledge to rank the proceedings of the food test on reducing sugars while 93% indicated to have had developed the appropriate knowledge to make conclusions from the observations during the practical food test on reducing sugars.

This implied that the appropriate knowledge was developed by learners during the practical food test on reducing sugars when using the MSL kits. Section 4.5.7 presents findings from the t-test and the one-way ANOVA on the development of the appropriate knowledge.

4.6.7 Presentations of findings from the t-test and the one-way ANOVA on the development of the appropriate knowledge by learners during the practical test on reducing sugars when using the MSL kits.

A Comparison of teachers and learners responses on knowledge development by learners was statistically significant ($t = .675$, $df = 177$, $p = 0.000$). Learners had a higher score (13.85± 3.94) on the development of the appropriate knowledge than teachers (13.08 ±4.44).

A Comparison within the group of learners (males and females) on the responses about the acquisition of knowledge was not statistically significant (t = -1.186, df = 164, p = 0.237). Female learners had a higher score (31.90 ±7.63) on the development of knowledge than the male learners (13.60 ± 4.02).

A Comparison of male and female teachers' responses on the learners developed appropriate knowledge was statistically significant (t = 1.08, df = 11, p =0.004). Male teachers had a higher score (13.80 ± 4.85) on the development of the appropriate knowledge than the female teachers (10.67 ± 1.16).

A comparison of means and standard deviation indicated a significant difference in the development of appropriate knowledge by schools SS1 (13.25 ± 2.95), SS2 (12.70 ± 3.74), SS3 (13.61 ± 3.87), SS4 (17.03 ± 4.94). F (3, 162) =.9.71, P= .000.

Comparing the Means and standard deviation of responses of learners by age on the development of knowledge indicated no significant difference by age. Below 16 years (13.25 ± 3.81), sixteen to twenty years (13.81 ± 3.97), above 20 years (15.13 ± 3.94).There was no significant difference in the development of the appropriate knowledge by age (df= 2, F= .516, p= .596)

Comparing the Means and standard deviation by grades of learners on the development of knowledge indicated no significant difference, Grade 11 (12.79 ± 3.70) and Grade 12 (14.57 ± 3.95). However, the ANOVA suggested a significant difference (df = 1, F = 8.49, P= .004).

A comparison of means and standard deviation by gender within learners on the development of knowledge indicated no significant difference. The scores were 13.50 ± 4.01 for males and, 14.55 ± 3.73 for females. The ANOVA findings showed d1f = 1, F = 2.596, P= .109

4.7: Findings on Research Question 3

This section presents findings on research Question 3

Research Question 3 was "What stimulation is developed by learners in a practical test on reducing sugars when using the MSL kits?"

In order to answer Research Questions 3 learners and teachers were given questionnaires to rate the stimulation of learners during a practical test on reducing sugars. Observations were conducted by the researcher during the practical test on reducing sugars while using the MSL kits using the observation schedule. Interviews were also conducted on a few learners and teachers using the interview guide in order to ascertain the stimulation developed by learners.

Appendix N presents the ratings by learners on the stimulation they had developed during the practical test on reducing sugars. It illustrates the frequency and percentage ratings. It shows that on average 49% strongly agreed and 33% agreed that they developed stimulation. However, 9% were not sure while 3% disagreed and 2% strongly disagreed that they developed stimulation. This implied that many learners claimed to have had been stimulated during a practical test on reducing sugars by the use of the MSL kit.

Appendix O presents the ratings by teachers on the stimulation developed by learners. In addition, it presents the frequency and percentage ratings. It shows that the respondents strongly agreed that learners were stimulated when they were testing food for reducing sugars. However, a few disagreed. This indicated that learners were stimulated during a practical test on reducing sugars by the use of the MSL kits.

Appendix P presents the ratings by the researcher using the observation schedule on the stimulation developed by learners. In addition, it presents the frequency and percentage ratings. It shows that the researcher strongly agreed that learners were stimulated when they were testing food for reducing sugars, as is evidenced in Appendix E. This indicated that learners got stimulated during a practical test on reducing sugars by the use of the MSL kits. Section 4.6.1 are the findings from the interviews about the stimulation by learners during a practical test on reducing sugars while using the MSL kits

Findings from the interviews about the stimulation developed by learners during a practical test on reducing sugars while using the MSL kits

4.7.1 Learners' feelings during the practical test on RS when using the MSL kits

Having interviewed the learners in reference to Question (v) of appendix D. A question which sought to bring out the stimulation developed by learners during the practical test on reducing sugars when using the MSL kits.

Out of the 61 learners who were interviewed 34 representing 59 % were stimulated to pursue biological careers. And 17 were not stimulated representing 29 %. While, 7 were not sure if they were stimulated representing 12 % during the practical test on reducing sugars when using the MSL kits. This is what some of the learners had to say;

PP 47 happily said;

> *...I enjoyed the practical…*

In contrast PP 59 said:

> *...I felt bad because of the large group because the concentration was not much…*

And PP 59 continued to say:

> *...If it was done individually it was going to be ok. I would love to do a biological career which is nursing...*

With a similar view *PP* 8 said:

> *… I felt bad, the teacher made a group of 15 … should be at least 3 or 5 in order to concentrate …*

However, PP 20 with mixed feelings lamented:

> *… I felt happy and scared because I was doing the right thing … I got interested in doing so that when I finish school I can be doing that, I want to be a doctor because maybe you can conduct a practical to test sugar disease as a result of too much sugar…*

But PP 21 excitedly said:

> *… I was very stimulated… and felt as though I work in the laboratory. Even before, I had thought of pursuing a biological career but after the practical the interest increased...*

Meanwhile, PP 9 said:

> *…I felt bad and was scared because at first the reducing sugars were absent…but when they were present I felt good … and the need to pursue a biological career which helps me to know what food nutrients are present. This practical tells me my career will be fulfilled…*

Views of HODS and teachers of biology

PT1 positively said:

> *Yes … they got excited and ask a lot of question and ask for more practicals…It also increased curiosity… they were trying on their own especially if the results were not showing…*

In addition, PT2 said:

> *Yes it depends on the learners some were stimulated others were not … this was seen from the participation … it was average … they were stimulated to pursue biological careers … For sure the lesson increased curiosity because most of them were saying they would like to continue doing practicals often.*

Further PT3 in line with PT 1 lamented:

> *…yes they were stimulated the indicators they show excitement and anxiety to take part in the practicals especially that they don't have conventional labs for them that look like they are also given that privilege and get a rare opportunity they feel like they are part of the secondary school they doing those things that are real life because they do things that are theory…they feel excited …they also get hands on the equipment before they are even told to conduct practicals… I wouldn't tell if they were stimulated to pursue*

biological careers because they have different career interests…the lesson increased curiosity they were looking forward to when they were going to do more practicals…

The views from some learners and some teachers indicated that the use of MSL kits during the practical test on reducing sugars stimulated learners. Figure 4.4 illustrates learners' stimulation during the practical test on reducing sugars when using the MSL kits

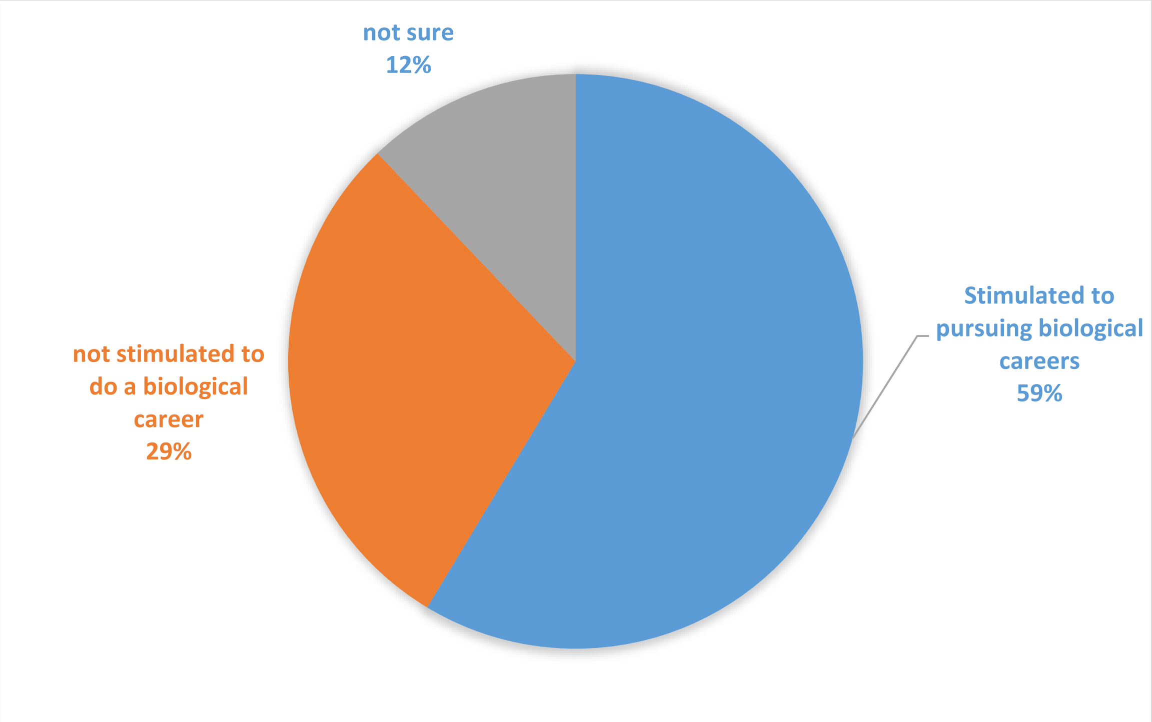

Figure 4.4: Stimulation of learners

Source: Field data (2018)

Figure 4.4 shows that 59% of the 61 learners who were interviewed were stimulated to pursuing biological careers. Meanwhile, 29% were not stimulated to do biological career and 12% were stimulated by the practical but not stimulated to pursue a biological career. This indicated that the use of the MSL kits during the practical test on reducing sugars stimulated learners to pursue biological careers.

4.7.2 Biological careers learners were stimulated to pursue after the practical test on reducing sugars when using the MSL kits

In order for the researcher to be certain about the responses that learners had given, she further asked them to state any careers related to biological sciences. According to them these were the careers; nursing, agroforestry, veterinary medicine, microbiology, laboratory technician, biology teacher, pharmacy, biomedicine, clinical medicine, agriculture, medicine, scientist/researcher, farmer, engineering, biochemistry, food technologist.

Of the 34 respondents who had indicated that they were stimulated by the practical test on reducing sugars when using the MSL kits. Six out of 34 representing 17% wanted to do nursing and 2 out of 34 wanted to be laboratory technicians/assistants representing 6 % with another 2 out of 34 intended to pursue agriculture science and another 2 out of 34 showed intentions of studying engineering representing a further 6 %. Those who intended to pursue teaching as teachers of biology were 3 out of 34 representing 9%. In the field of pharmacy, biomedicine, clinical medicine, research, biochemistry and food technology only one for each career representing 13 % for each. Meanwhile 13 out of 34 wanted to do medicine representing 38 %.

These were some of their views:

i. *... I would love to do a biological career which is nursing.*

ii. *When conducting the practical test, I thought of doing a biological career which is pharmacy.*

iii. *... Yes it brought interest in me doing biochemistry in future, biochemistry has information on reducing sugars.*

iv. *... I want to study medicine because it's in line with biology and this practical*

v. *....yes I want to do medicine to become a medical doctor…after the practical I felt I could even arrange medicine for the patients my career was really developed.*

vi. *…highly motivated to be a food technologist* *vii. ...teacher of biology.*

Figure 4.5 shows some biological careers learners were stimulated to pursue after the practical test on reducing sugars when using the MSL kits

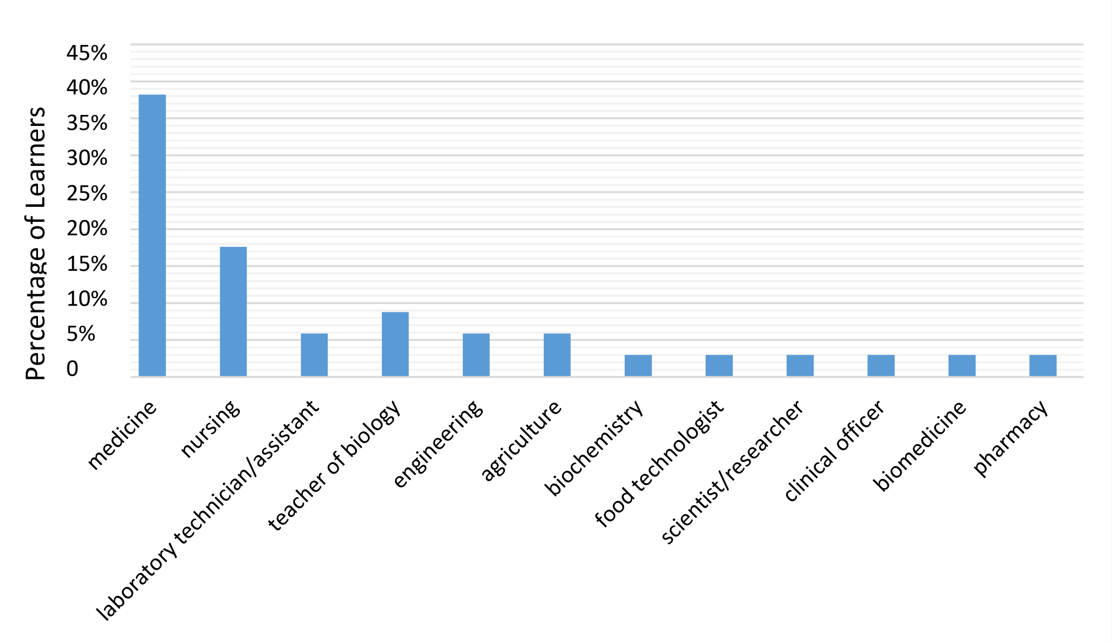

Figure 4.5: Biological careers learners were stimulated to pursue after the practical test on reducing sugars when using the MSL kits
Source: Field data (2018)

Figure 4.5 shows that 17% wanted to study nursing. Others represented by 6% each wanted to study either laboratory technicians/assistants, engineers or doing agriculture science. Those who intended to pursue teaching as teachers of biology were represented by 9 %. Other careers such as pharmacy, biomedicine, clinical medicine/officer, research, biochemistry and food technology were represented by 3% each. Meanwhile 38% wanted to study medicine. Section 46.3 presents findings from the t-test and the ANOVA about the stimulation developed by learners.

4.7.3 Presentation of findings by way of independent t-test and One-way ANOVA on the stimulation developed by learners during the practical test on reducing sugars when using the MSL kits

A Comparison of teachers and learners responses on the stimulation developed by learners showed that t = -0.218, df = 177, and p =.828 in this case t was not statistically significant. Based on examining the means, teachers had a higher score (11.92 ± 4.50) than learners (11.70 ± 3.50) about stimulation developed by learners.

A Comparison within a group of learners on their responses about stimulation during a practical test on reducing sugars when using the MSL kits showed that t = -0.403, df = 164, and p =.687 in this case t was not statistically significant. Based on examining the means, female learners have a higher score (11.85 ± 3.65) on the stimulation developed than male learners (11.62 ± 3.43).

A Comparison of male and female teachers responses on the stimulation developed by learners during a practical test on reducing sugars when using the MSL kits showed that t = 2.12, df = 11, p =.057 in this case t was statistically significant. So, based on examining the means, male teachers had a higher score (13.20 ± 4.37) on stimulation developed by learners than female teachers (7.67 ± 58).

The one-way ANOVA showed that df= 3, F = 10.52, P= .000. This implied that there was a significant difference in the stimulation of learners among schools.
A comparison of means and standard deviation of responses of learners by age on the stimulation developed showed that the scores were 12.00 ± 3.51 for the ages below 16, it was 11.66 ± 3.54 for ages 16 to 20 and 12.13 ±12.13 for ages above 20. There was no indication of significant difference in the stimulation developed by learners due to age df = 2, F = 0.97, P= .907.

A comparison of means and standard deviation by grades on the stimulation attained within learners showed that the scores were 11.22 ± 3.38 for grade 11 and 12.02 ± 3.56 for grade 12. This indicated no significant difference in the development of stimulation by learners due to grade. The one-way ANOVA showed df =1, F = 2.09, P= .151. This implied that there was no significant difference in the stimulation of learners by grade

A comparison of means and standard deviation by gender within learners on the stimulation attained showed that the scores were 11.55 ± 3.45 for males, 12.00 ± 3.61 for females. The one-way ANOVA showed df = 1, F = .609, P= .436. This implied that there was no significant difference in the stimulation of learners by gender. Section 4.6.4 presents the General views regarding the use of MSL kits.

4.7.4 General views regarding the use of MSL kits

As the interviews progressed the researcher was further prompted to ask a probing question regarding the use of the MSL kits. Below is the summary of the learners' views.

a. *MSL are okey, they are helping us in learning … you can't do practicals without the MSL because they are moved from class to class.*
b. *We face challenges when using the MSL kits because we need to move them frequently. However, if we didn't have MSL kits we wouldn't have known how to conduct practicals on reducing sugars… Government has done well to bring them because we are now seeing what is happening*
c. *The Government has done well to bring MSL kits because I learn*
d. *Even if someone is from a school with conventional laboratory we are doing the same practicals and therefore we thank the Government.*
e. *The Government has done well to bring MSL kits to this newly upgraded secondary school because without these MSL kits we wouldn't have conducted this practical on reducing sugars. However, I feel we need to have a conventional laboratory which is bigger where everyone would be fitting when doing practicals.*
f. *The Government should bring more MSL.*
g. *It has been a good idea by the Government to have brought*
h. *MSL kits are really helping us because we can do practical just like those with conventional laboratories*
i. *I wouldn't have an idea on how to go about with lab work, anyway its benefitting us.*
j. *…MSL helps us to do practical we are unable to do practical because we do not have conventional laboratories …*
k. *...need to have a laboratory because the classroom is small and not everyone participates as most practical are done in groups you learn well as an individual.*
l. *…it's easy to carry the apparatus and specimens to the class and conduct the practical.*

m. *...not beneficial because it is just used once in a while. However, I wouldn't have an idea on how to go about with lab work, anyway its benefitting us.*

n. *… MSL kits are really helping us because we can do practical just like those with conventional laboratories*

These responses indicate that the government did well to give MSL kits to the newly upgraded secondary schools in Chinsali District.

4.8 Summary of the chapter

Chapter 4 presented the findings about the development of SPS, knowledge and stimulation in learners during a practical test on reducing sugars when using the MSL kits. Comparing the averages about learners' acquisition of science process skills, knowledge and stimulation indicated that many learners developed the appropriate science process skills, knowledge and stimulation with only a few learners not acquiring them. Test for significant difference by way of independent t-test indicated that there was no statistical difference. However, the One-way ANOVA showed a significant difference in the development of the appropriate knowledge and stimulation among schools. The next chapter discusses these findings.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

The previous chapter elaborated the analysis of the data and its interpretation. This chapter discusses the findings in line with the research objectives.

5.2 Discussion of findings

The first issue the study sought to establish was the developed appropriate SPS in learners when using the MSL kits during a practical test on reducing sugars. The second issue was to establish the developed appropriate knowledge in learners when using MSL kits during a practical test on reducing sugars. Thirdly, the study sought to establish the stimulation developed by learners during a practical test on reducing sugars when using the MSL kits.

5.2.1 Developed science process skills by learners during the practical test on reducing sugars when using the MSL kits

The findings of the study by comparing the averages of frequencies and the percentages in Appendix H showed that many learners developed the science process skills where 85% of the learners agreed, and 11% of the learners were not sure while only 4% disagreed that they had acquired the science process skills. These findings showed that more learners rated high the option for statements related to the skill of experimenting where 94% of the learners agreed that they had developed the experimenting skills to perform the procedure of the experiment on powdered food sample. Another option rated high on experimenting was the statement that they had developed the skill to use a hot water bath appropriately where 91% agreed. Additionally, another 91% of the learners agreed that they had developed the skill to perform the procedure on the experiment on solid food samples. The other option rated high was the statement that learners had acquired the skill to follow the appropriate experimental procedures where 93% agreed, second in ranking in the developed SPS was communication rating high was the statement that they had acquired the skill to follow the given instructions where 89% learners agreed while 7% were not sure and only 4% disagreed. Third in the ranking of the developed SPS was observation with the statement that learners acquired the skill to identify the colour changes where 60% strongly agreed and 34% agreed while 6% were not sure and only 1% disagreed and none of the learners strongly disagreed. This was followed by the skill to measure, inference and predicting. The least developed SPS was classifying with the statement that they acquired the skill to classify carbohydrates as monosaccharides, disaccharides and polysaccharides. Where only 61% agreed while 30% were not sure and only 8% disagreed.

This was evident from the learner's views as presented in Figure 4.2. It shows that 82% of the learners had developed the experimenting skill and 66% developed the measuring skill. About 54% had developed the observation skill. Another 54% developed the communication skills. However, 41% had developed the inference skill while 38% of learners had developed predicting skill. On the other hand, only 33% learners developed the skill to classify.

A comparison of the average and percentages of the teachers' responses in Appendix I showed that many learners developed the SPS where 93% of the teachers agreed while the remaining 7% were not sure if their learners had developed the SPS.
Ranked highly of the developed SPS was observation followed by communication, predicting, experimenting and inference. This conformed to the learning theory of Bandura (1977) as it posits that people learn from one another, via observations, imitations and modelling. However, the least developed SPS was classify. These findings revealed that the use of MSL kits during a practical test on reducing sugars by learners developed the appropriate SPS.

The findings of the study shown in Appendix J from the observations and in reference to Appendix E. The implication is that on the average a higher percentage of learners developed the SPS of observation, communication, experimenting, measuring, inference, and predicting. However, only a few learners developed the skill to classify.
Although the findings of the study as presented in Appendix H, Appendix I, and Appendix J. using the three different instruments established that the SPS to classify was not developed by many learners. It is optimistic to assume that the use of the MSL kits during a practical test on reducing sugars by learners gave them an opportunity to develop the SPS. Therefore, triangulation using the three different instruments of data collection was a way of ensuring validity and credibility of the research findings. This enabled the researcher to have confidence that concurrent triangulation design yielded good results (Ghosh, 1992).

These findings show that the use of MSL kits during a practical test on reducing sugars enabled learners to develop the appropriate SPS. They found the skill of experimenting, communication and observation easier than the other skills. These results collaborate those of (Karamaustafauglo, 2011) who conducted a study in Turkey and found that the experimenting skill was at the highest level of acquisition in student teachers among the integrated SPS and slightly different to the results of (Hafez & Rashed, 2014) who found that a few Palestinian secondary school students selected the correct option for items related to the skill of experimenting while more of the students selected the correct option for the items related to the skill of observation, predicting and measuring .Although Karamaustafauglo and Hafez seemed to have slight different findings there was an indication that in both cases SPS were developed. In contrast, Hudson, (1990) argues that laboratory work is not about teaching students to observe, classify and, measure but they know this. Further (Hudson 1990) adds that laboratory work and practical are a waste of time.

Therefore, failure by many learners to develop the skill to classify gives a question to the researcher on how best learners could be assisted in order to develop this skill. It is for this reason that the researcher believe that research should be done in future to ascertain the cause to this.

The findings as presented in Section 4.4 by way of independent t-test revealed that t was statistically significant, which means there was no statistical significant difference in the development of SPS by learners during a practical test on reducing sugars when using the MSL kits.

This section also showed that there was no significant mean difference in the development of the SPS among schools, age, grade and gender. These findings revealed that learners in all the schools under study did not differ in the development of SPS despite the differences in their age, grade and, gender.

The findings by one way analysis of variance (ANOVA) indicated that there was no significant difference in the development of SPS among schools, age, grade and gender. This meant that despite learners coming from different schools with different ages, grade and, gender. They developed the SPS during a practical test on reducing sugars when using the MSL kits. These findings relate to the findings of the study conducted by Al-rabaani (2014) whose results showed that students had a moderate acquisition of SPS and there was no difference due to gender.

The researcher believed that there was no difference in the development of SPS because learners were exposed to the similar learning environment where they were all using the same type of equipment and materials. This is in line with the assertion by Tobin (1990) who suggested that; meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials in an environment suitable.

5.2.2 Appropriate knowledge developed by learners in a practical test on reducing sugars when using the MSL kits.

Secondly, the study sought to establish the appropriate knowledge developed by learners when using the MSL kits during a practical test on reducing sugars. The findings of the study by comparing the averages of frequencies and the percentages in Appendix K revealed that many learners (90%) agreed that they had acquired the appropriate knowledge to differentiate reducing sugars from non-reducing sugars and 95% of the learners agreed that they had acquired the knowledge to make the conclusion from the observations of the experiment. Ninety two percent of the learners also agreed that they had acquired the knowledge to explain the measure of the required volume of the reagent and the food sample. However, a few learners (63%) agreed that they had acquired the knowledge to understand what reducing sugars are. An average of 83% learners agreed that the use of the MSL kits during a practical test on reducing sugars developed the appropriate knowledge.

Results in Appendix L revealed that many teachers (92%) agreed that learners had acquired the knowledge to explain the procedures involved in the practical test on reducing sugars and also the knowledge to explain the measure of the required volume of the reagent and the food sample. A good number of teachers (93%) strongly agreed that learners had acquired the knowledge to rank the proceedings of the practical test on reducing sugars even the knowledge to differentiate reducing sugars from non-reducing sugars and the knowledge to make conclusions from the observations of the experiment. However, few teachers (69%) agreed that the learners had acquired the knowledge to understand what reducing sugars are.

The observations results as indicated in Appendix M confirmed that learners had acquired the knowledge to make the conclusions from the observations of the experiment. Learners also developed the knowledge to explain the measure of the required volume of the reagent and the food sample. The observations in reference to Appendix E further confirmed that learners had developed the knowledge to explain the procedure involved in the practical test on reducing sugars and the knowledge to differentiate reducing sugars from non-reducing sugars

Some views from the participants (54, 46, 28, 30, and 48) indicated that the appropriate knowledge was acquired by learners as can be seen in Figure 4.3.

In view of these findings, the researcher strongly believe that learners developed the appropriate knowledge during a practical test on reducing sugars when using the MSL kits. This conforms to the theory under which this study was rooted Bandura (1977) which has often been called the bridge between behaviourist and cognitive learning theory. This theory encompasses attention, and memory. The researcher strongly believed that during the practical test on reducing sugars learners' behaviour changed so as to develop the SPS which further made learners to interpret knowledge. These findings agree with the findings by Dennis e*t.al* (2017) whose assertions are that the Intergration of SPS in teaching assists learners to retrieve prior knowledge and anchor new incoming information in the cognitive frame work. The findings also conform to the findings of researchers such as Motlhabane and Dichaba (2013) who claimed that studies conducted globally show the pivotal role played by laboratory work in enhancing science concepts. However, this is contrary to the findings by Changwe, (2008) who found that the science kits distributed to Zambian basic schools in 2003 were not used to reinforce learners understanding of science concepts.

The findings from the t-test showed a significant difference in the development of knowledge within learners where female learners had a higher score than male learners. The researcher attributes this to a notion that the preferred science subject by females is biology because it is believed that most concepts are just memorised and most female learners prefer memorisation because many teachers of biology prefer non-practical oriented lessons. However, the findings do not conform to the assertions by (Jovanovich & King 1985) that; girls handle laboratory equipment less frequently than boys and this tendency is associated with less interest and less self confidence in science ability among girls.

The one way ANOVA revealed that there was a significant difference in the development of the appropriate knowledge among schools and grade of the learners. The researcher believes that the difference among schools could be as a result of location of schools because among the schools studied, two were in the town set up while two are in the rural set up .So, those in the town set up might have access to different communication facilities as well as literature related to the topic that may widen their conceptual understanding, unlike those in the rural set up. This difference was further attributed to how frequent the MSL kits are used because some respondents indicated that they mostly used these kits during mock and final exams.

The researcher strongly attributes the difference mostly to the way some science teachers teach without exposing their learners to practical work. This is in conformity with a study conducted in Kenya which showed that students were less exposed to practicals during lessons (Rutto & Kptingel 2013). In addition, the way some science teachers teach lessons encourages memorisation instead of investigative oriented learning (Hofstein & Mamlok-Naaman 2007).

The researcher attributes the difference due to grade in the level of education of the sampled learners. During the study, the grade 12s had learnt more topics than grade 11s.Therefore, grade 12s had more conceptual knowledge than grade 11s.

5.2.3 The stimulation developed by learners when using the MSL kits during the practical test on reducing sugars.

Thirdly, the study sought to establish the stimulation developed in learners when using the MSL kits during the practical test on reducing sugars. The findings of the study by way of comparing the average frequencies and percentages in Appendix N and Appendix O revealed that a good number of both learners (93%) and teachers (93%) agreed that learners were stimulated to develop a positive attitude towards experiments and reducing sugars while 92% of learners and 100% of teachers agreed that learners were stimulated to develop curiosity to learn more on reducing sugars. In addition, 88% of the learners agreed that they had been stimulated to develop an interest to work hard in biology with 79% of learners and 90% of teachers agreed that learners were stimulated to pursue a biological career dealing with reducing sugars. Meanwhile 79% of learners agreed that they had been stimulated to develop creativity on carrying out practical test on reducing sugars.

Generally, an average 87% of learners and 83% of teachers agreed that the use of MSL kits during a practical test on reducing sugars stimulated learners and, only 4% of learners with 1% of teachers disagreed that learners were stimulated.

In reference to Appendix P the observation that were conducted showed that a good number of learners were stimulated to develop a positive attitude towards experiments and reducing sugars. It was also observed that learners were stimulated to develop creativity on carrying out practical test on reducing sugars and to develop interest to work hard in biology (also refer to Appendix E).

This was evident even from the views of learners PP 59, 8, 20, 21, and teachers PT 3, 2 and 13. These findings revealed that the use of MSL kits during a practical test on reducing sugars stimulated learners. All this implied that Banduras (1977) theory was of significance to this study as it also encompasses motivation. Therefore, the researcher believed that as learners were engaged in the practical lesson, during the proceedings of the practical they were stimulated to follow the procedure so as to finally make correct conclusions about the findings. The stimulation made learners interested in the practical proceedings and finally motivated to learn more. This is in line with the findings of the study conducted by (MV foundation, 2012) in Hyberdan which revealed that the MSL project increased students' interest and enthusiasm in science subjects when they were using the MSL.

The independent t-test on the development of stimulation was not statistically significant. However, the one way ANOVA findings revealed that there was a statistically significant difference in the stimulation of learners among schools because $p < .05$. This is in line with the findings of the study conducted by Hafez and Rashed (2014) in Palestine on Palestinian secondary school students were $p< .05$ revealing that village students were interested in learning and thus acquiring SPS. The difference in the findings might be attributed to the attitude of some science teachers towards conducting practicals (Jones & Stapleton 2017). Jones & Stapleton (2017) further reported that ML programs with their focus on hands-on, inquiry-based instruction will be effective at increasing student interest in STEM.

5.3 Summary of the chapter

This chapter discussed the findings about the developed appropriate SPS, knowledge and stimulation by learners during a practical test on reducing sugars when using the MSL kits. It was evident that when used in schools that do not have conventional laboratories, these kits enabled learners to develop the appropriate SPS and knowledge. The MSL kits also stimulated learners.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The research intended to explore the development of SPS, knowledge and stimulation by learners during the practical test on reducing sugars when using MSL kits in selected schools of Chinsali District of Muchinga Province. This chapter illustrates the conclusions and the recommendations in line with the research findings.

6.2 Conclusion

The findings in this study revealed that the appropriate SPS were developed by learners during a practical test on reducing sugars when using the MSL kits. Ranked high was the skill of experimenting, observation, and communication, this was followed by inference, predicting and measuring. While, the least developed SPS was classifying. On average 85% of the learners and 93% of the teachers agreed that learners developed the SPS. Furthermore, the findings revealed that the appropriate knowledge was acquired by learners because on average 83% of learners and 87% of teachers agreed that learners had developed the appropriate knowledge. In addition, the findings revealed that learners were stimulated during a practical test on reducing sugars where on average 87% of learners and 83% of teachers agreed. These results can be concluded in unison by a similar remark from MV Foundation project that the MSL Project in India has increased students' interest and enthusiasm in science subjects and improve their performance by enhancing their conceptual practical understanding of the topic taught.

Therefore, based on the findings of this study, when MSL kits are used during a practical test on reducing sugars, SPS are developed in learners as well as the appropriate knowledge. Additionally, learners get stimulated during a practical test on reducing sugars when using the MSL kits. This implies that lacking the MSL kits in the newly upgraded secondary schools would deprive the learners in developing the SPS, conceptual understanding and stimulation (Maseko 2014). In conclusion, absence of laboratory equipment would negatively impact the overall performance of learners.

6.3 Recommendations

In view of the findings of the study, the following recommendations are made:

1. More MSL kits should be procured by MOGE and be distributed to all newly upgraded secondary schools.
2. Teachers should be conducting regular practical sessions using MSL kits with learners in order for them to develop the SPS, conceptual knowledge and stimulation.
3. Teachers of biology should ensure that learners are exposed more to hands on activities using MSL kits in order to relate theory to practice.
4. Further research should be conducted in other Districts of Zambia in order to verify these findings on the use of MSL kits

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APPENDICES

Appendix A: Questionnaire for Learners

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

Dear Respondent my name is **NKOLE CATHERINE MUTALE,** I am a final year student at the University of Zambia pursuing a Degree of Master of Science with Education. I am currently conducting a study **"Assessing the extent to which mobile science laboratory kits develop learners' science process skills, knowledge and stimulation on test for reducing sugars: A case of selected secondary schools in Chinsali District."** I am kindly requesting you to respond to questions in this questionnaire. The information obtained is for academic purposes only and will help make this project a success. The respondent's identity will be kept confidential. For further clarification you can contact me on:

CELL: 0968 877115

Section A: Demographic data

1. Gender: male [ ]   female [ ]
2. Age : Below 16 [ ];   16-20 years [ ] Above 20 years [ ]
3. School: …………………
4. Grade: 11[ ];   12 [ ]

Section B:

1. Table A shows the science process skills that can be developed in learners during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

TABLE A:

Science process skills	**Statement**	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**Strongly disagree**
Observation	I have acquired the skill to identify the colour changes					
	I have acquired the skill to describe what is seen					
Measuring	I have acquired the skill to measure the right volume of benedict solution					
	I have acquired the skill to measure the right volume of the food sample solution					
Classifying	I have acquired the skill					

	to classify carbohydrates as monosaccharides, disaccharides and polysaccharides					
	I have acquired the skill to categorize carbohydrates as either reducing sugars or non reducing sugars or starch					
Inference	I have acquired the skill to identify reducing sugars and non reducing sugars					
	I have acquired the skill to draw conclusion if - the given food sample is a reducing sugars or not					
Predicting	I have acquired the skill to predict the outcome if reducing sugars are present or not					

Communication	I have acquired the skill to desc					
	I have acquired the skill to follow the given instructions					
	I have acquired the skill to give scientific explanation on why there is a colour change if reducing sugars are present					
experimenting	I have acquired the skill to follow the appropriate procedure					
	I have acquired the precautional skills of adding the right volume of benedict solution to the sample solution					
	I have acquired the skill to use the Bunsen burner appropriately					
	I have acquired the skill to perform the procedure on the experiment on solid food samples					
	I have acquired the skill to use a					

	hot water bath appropriately					
	I have acquired the skill to perform the procedure of the experiment on powder food samples					

2. Table B shows the appropriate knowledge that can be acquired in learners during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table B:

	Strongly agree	**Agree**	**Not sure**	**Disagree**	**Strongly disagree**
I have acquired the knowledge to understand what reducing sugars are					
I have acquired the knowledge to describe the procedure involved in this practical					
I have acquired the knowledge to explain the procedures involved in this practical					
I have acquired the knowledge to explain the measure of the required volume of the reagent and the food sample					
I have acquired the knowledge to describe the colour changes in this practical					
I have acquired the knowledge to rank the proceedings of the practical					
I have acquired the knowledge to differentiate reducing sugars from non- reducing sugars					
I have acquired the knowledge to make the conclusion from the observations of the experiment					

3. Table C shows the stimulation that learners can attain during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table C:

Statements	**strongly agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
I have stimulated to pursue a biological career dealing with reducing sugars					
mulated to develop a positive attitude rds experiments and reducing sugars					
I have been stimulated to develop an interest to work hard in biology					
I have been stimulated to acquire a detailed understanding of reducing sugars					
I have been stimulated to develop curiosity to learn more on reducing sugars					
I have been stimulated to develop creativity on carrying out practical test on reducing sugars					
I have been stimulated to eradicate superstition					

THE END

THANK YOU

Appendix B: Questionnaires for Teachers and HODs

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

Dear Respondent my name is **NKOLE CATHERINE MUTALE,** I am a final year student at the University of Zambia pursuing a Degree of Master of Science with Education. I am currently conducting a study **"Assessing the extent to which mobile science laboratory kits develop learners science process skills, knowledge and stimulation on test for reducing sugars: A case of selected secondary schools in Chinsali District."** I am kindly requesting you to respond to questions in this questionnaire. The information obtained is for academic purposes only and will help make this project a success. The respondent's identity will be kept confidential. For further clarification you can contact me on:

CELL: 0968 877115

Section A: Demographic data

1 Gender: male [ ] female [ ]

2 Status: HOD [ ]; Biology teacher [ ]

3 School: …………………

Section B:

1. Table A shows the science process skills that can be developed in learners during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

TABLE A:

SCIENCE PROCESS SKILLS	**STATEMENTS**	**Strongly Agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
OBSERVATION	Learners have acquired the skill to identify the colour changes					
	Learners have acquired the skill to describe what is seen					
MEASURING	Learners have acquired the skill to measure the right volume of benedict solution					
	Learners have acquired the skill to measure the right volume of the food sample					
CLASSIFYING	Learners have acquired the skill to classify carbohydrates as monosaccharides,					

	disaccharides, and polysaccharides					
	Learners have acquired the skill to categorise carbohydrates as either reducing sugars or non-reducing sugars or starch					
INFERENCE	Learners have acquired the skill to identify reducing sugars and non-reducing sugars after the experiment					
	Learners have acquired the skill to draw the conclusion if the given food sample is a reducing sugar or not					
PREDICT	Learners have acquired the skill to predict the outcome if reducing sugars are present or not					
COMMUNICATION	Learners have acquired the skill to describe the findings after the experiment on reducing sugars					
	Learners have acquired the skill to follow the given instructions					
	Learners have acquired the skill to give scientific explanation on why there is a colour change if reducing sugars are present					
EXPERIMENT	Learners have acquired the skill to follow the					

	appropriate procedure					
	Learners have acquired the precautional skills of adding the right volume of benedict solution to sample solution					
	Learners have acquired the skill to use the Bunsen burner appropriately					
	Learners have acquired the skill to use a hot water bath appropriately					
	Learners have acquired the skill to perform the procedure of the experiment on solid food samples					
	Learners have acquired the skill to perform the procedure of the experiment on powder food samples					
	Learners have acquired the skill to perform the procedure of the experiment on liquid food samples					

2. Table B shows the appropriate knowledge that can be acquired by learners during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table B:

STATEMENTS	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Learners have acquired the knowledge to understand what reducing sugars are					
Learners have acquired the knowledge to describe the procedure involved in this practical					
Learners have acquired the knowledge to explain the procedures involved in this practical					
Learners have acquired the knowledge to measure of the required volume of the reagent and the food sample					
Learners have acquired the knowledge to describe the colour changes in this practical					
Learners have acquired the knowledge to rank the proceedings of the practical					
Learners have acquired the knowledge to differentiate reducing sugars from non- reducing sugars					
Learners have acquired the knowledge to make the conclusion from the observation of the experiment					

3. Table C shows the stimulation that learners can attain during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table C:

STATEMENTS	**Strongly agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
Learners have been stimulated to pursue a biological career dealing with reducing sugars					
Learners have been stimulated to develop a positive attitude towards experiments and reducing sugars					
Learners have been stimulated to develop an interest to work hard in Biology					
Learners have been stimulated to acquire a detailed understanding of reducing sugars					
Learners have been stimulated to develop curiosity to learn more on reducing sugars					
Learners have been stimulated to develop creativity on carrying out practical test on reducing sugars					
Learners have been stimulated to eradicate superstition					

THE END

THANK YOU

Appendix C: Observation Schedule

SECTION A: Demographic data

1. **Grade: 11 [ ]; 12 [ ]**
2. **School:**

SECTION B:

1. Table A shows the science process skills that can be developed during a practical test on reducing sugars while using the Mobile Science Laboratory kits.

*Rate how far you agree or disagree whether the learners have acquired these science process skills by ticking appropriately.

Table A:

SCIENCE PROCESS SKILLS	STATEMENTS	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree
OBSERVATION	Learners have acquired the skill to identify the colour changes					
	Learners have acquired the skill to describe what is seen					
MEASURING	Learners have acquired the skill to measure the right volume of benedict solution					
	Learners have acquired the skill to measure the right volume of the food sample					
CLASSIFYING	Learners have acquired					

	the skill to classify carbohydrates as monosaccharides, disaccharides, and polysaccharides					
	Learners have acquired the skill to categorise carbohydrates as either reducing sugars or non-reducing sugars or starch					
INFERENCE	Learners have acquired the skill to identify reducing sugars and non-reducing sugars after the experiment					
	Learners have acquired the skill to draw the conclusion if the given food sample is a reducing sugar or not					
PREDICT	Learners have acquired the skill to predict the outcome if reducing sugars are present or not					
COMMUNICATION	Learners have acquired the skill to describe the findings after the experiment on reducing sugars					
	Learners have acquired the skill to follow the given instructions					
	Learners have acquired the skill to give scientific explanation on why there is a colour change if					

	reducing sugars are present					
EXPERIMENT	Learners have acquired the skill to follow the appropriate procedure					
	Learners have acquired the precautional skills of adding the right volume of benedict solution to sample solution					
	Learners have acquired the skill to use the Bunsen burner appropriately					
	Learners have acquired the skill to use a hot water bath appropriately					
	Learners have acquired the skill to perform the procedure of the experiment on solid food samples					
	Learners have acquired the skill to perform the procedure of the experiment on powder food samples					
	Learners have acquired the skill to perform the procedure of the experiment on liquid food samples					

2. Table B shows the appropriate knowledge that can be acquired by learners during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table B:

STATEMENTS	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Learners have acquired the knowledge to understand what reducing sugars are					
Learners have acquired the knowledge to describe the procedure involved in this practical					
Learners have acquired the knowledge to explain the procedures involved in this practical					
Learners have acquired the knowledge to measure of the required volume of the reagent and the food sample					
Learners have acquired the knowledge to describe the colour changes in this practical					
Learners have acquired the knowledge to rank the proceedings of the practical					
Learners have acquired the knowledge to differentiate reducing sugars from non-reducing sugars					
Learners have acquired the knowledge to make the conclusion from the observation of the experiment					

3. Table C shows the stimulation that learners can attain during the practical test on reducing sugars while using the mobile science laboratory kits.

*Rate yourself how far you agree or disagree with the given statements by TICKING APPROPRIATELY.

Table C:

STATEMENTS	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
Learners have been stimulated to pursue a biological career dealing with reducing sugars					
Learners have been stimulated to develop a positive attitude towards experiments and reducing sugars					
Learners have been stimulated to develop an interest to work hard in Biology					

Learners have been stimulated to acquire a detailed understanding of reducing sugars					
Learners have been stimulated to develop curiosity to learn more on reducing sugars					
Learners have been stimulated to develop creativity on carrying out practical test on reducing sugars					
Learners have been stimulated to eradicate superstition					

THE END

Appendix D: Interview Guide

THE UNIVERSITY OF ZAMBIA

SCHOOL OF EDUCATION

Assessing the extent to which mobile science laboratory kits develop learners science process skills, knowledge and stimulation on test for reducing sugars: A case of selected secondary schools in Chinsali District

CELL: 0968 877115

(For learners)

i. Discuss how the practical test on reducing sugars was conducted when using the Mobile science laboratory kit.
ii. Discuss the differences between reducing sugars and non-reducing sugars.
iii. Describe the procedures involved in the practical test on reducing sugars when using the mobile science laboratory kits.
iv. At what point did you realise that reducing sugars were present in a food sample
v. Discuss what you felt during the practical test on reducing sugars when using the mobile science laboratory
vi. Discuss your ability to pursue a career in biological sciences after this practical activity on reducing sugars when using the mobile science laboratory kits
vii. Mention some careers related to biological sciences.
viii. How often you like would to be having practicals on reducing sugars when using the mobile science laboratory kits?

(For teachers of biology and HODs)

i. Were the learners able to discuss how the practical test on reducing sugars were conducted when using the Mobile science laboratory kit?
   What were the indicators?
ii. Were the learners able to discuss the differences between reducing sugars and non-reducing sugars?
   What were the indicators?
iii. Were your learners able to describe the procedures involved in the practical test on reducing sugars when using the mobile science laboratory kits?
   What are the indicators?
iv. At what point did the learners realise that reducing sugars were present in a food sample?
v. Were the learners stimulated during the practical activity on reducing sugars when using the Mobile Science Laboratory kits?
   ii. Give the indicators to the answer above
vi. i. Discuss the learners' ability to pursue career in biological science after the practical test on reducing sugars when using the Mobile Science Laboratory kits.
vii. Did the lessons on reducing sugars when using the Mobile Science Laboratory kits increase curiosity in learners? ………………………..
   Ii what are the indicators?

END

APPENDIX E: Learners Using MSL kits

Appendix F: Work Schedule

Date	Task
May-August 2017	Preparation for fieldwork • Submission of proposal • Data collection instruments completed
September 2017	Submission for ethical clearance
October 2017	Data collection • Questionnaires • Lesson observations
January 2018	Interviews
February 2018	Data Analysis begins • Data sorting • Data cleaning
March 2018	Report writing • Submit revised chapters (1,2 & 3)
April 2018	Presentation of findings • Seminar
July 2018	Submission for examination

Appendix G: Approval of Study

THE UNIVERSITY OF ZAMBIA

DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

Great East Road | P.O. Box 32379 | Lusaka 10101 | Tel: +260-211-290 258/291 777
Fax: +260-1-290 258/253 952 | Email: director@drgs.unza.zm | Website: www.unza.zm

Approval of Study

8th August, 2018

REF. No. HSSREC: 2018-JANUARY-002

Ms. Nkole Catherine Mutale
C/O The University of Zambia
P.O Box 32379
LUSAKA

Dear Ms. Mutale,

RE: "EVOLVING PROCESS SKILLS, KNOWLEDGE AND STIMULATION WHEN USING MOBILE SCIENCE LABORATORY DURING TEACHING AND LEARNING TO TEST FOOD FOR REDUCING SUGARS IN CHINSALI DISTRICT"

The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB resolved to **approve** this study **subject to corrections** and your participation as Principal Investigator for a period of one year.

Review Type	**Expedited Review**	**Approval No. HSSREC: 2018-JANUARY-002**
Approval and Expiry Date	Approval Date: 8th August, 2018	Expiry Date: 7th August, 2019
Protocol Version and Date	Version-Nil	8th August, 2018
Information Sheet, Consent Forms and Dates	• English.	To be provided
Consent form ID and Date	Version	To be provided
Recruitment Materials	Nil	Nil

There are specific conditions that will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Excellence in Teaching, Research and Community Service

Conditions of Approval

- Provide information sheets and consent letters as these were not attached. The information sheets should have had the essential features included. Please use the WHO templates which you could download at www.who.int/rpc/research_ethics/informed_consent/en/). REC would appreciate if the PI could customise the WHO templates and include the domains of what the submitted protocol is positing on tools and the sampling units (people who have been or shall be participating in this study.
- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved by an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review and approval. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by the IRB before they can be implemented.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB does not "stamp" approval letters, consent forms or study documents unless requested for in writing. This is because the approval letter clearly indicates the documents approved by the IRB as well as other elements and conditions of approval.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of The University of Zambia Humanities and Social Sciences Research Ethics Committee IRB, we would like to wish you all the success as you carry out your study.

Yours sincerely,

Dr. Jason Mwanza

BA, MSoc, Sc., PhD

CHAIRPERSON

THE UNIVERSITY OF ZAMBIA HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE IRB

Appendix H: Responses by learners on the acquisition of the science process skills during a practical test on reducing sugars when using the MSL kits

Science process skills	Statement	Strongly agree		Agree		Not sure		Disagree		Strongly disagree	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Observation	I have acquired the skill to identify the colour changes	99	60	56	34	10	6	1	1	0	0
	I have acquired the skill to describe what is seen	85	51	68	41	12	7	1	1	0	0
Measuring	I have acquired the skill to measure the right volume of benedict solution	84	51	60	36	17	10	3	2	2	1
	I have acquired the skill to measure the right volume of the food sample solution	75	45	67	40	18	11	4	2	2	1
Classifying	I have acquired the skill to classify carbohydrates as monosaccharides, disaccharides and polysaccharides	57	34	45	27	50	30	7	4	7	4
	I have acquired the skill to categorize carbohydrates as either reducing sugars or non reducing sugars or starch	55	33	49	30	50	30	8	5	4	2
Inference	I have acquired the skill to identify reducing sugars and non-reducing sugars	68	41	58	40	31	19	7	4	2	1
	I have acquired the skill to draw conclusion if -the given food sample is a reducing sugars or not	72	43	60	36	26	16	5	3	3	2
Predicting	I have acquired the skill to predict the outcome if reducing sugars are present or not	76	46	52	31	20	12	15	9	3	2
	I have acquired the skill to desc	99	60	45	27	13	8	4	2	4	2

Communication	I have acquired the skill to follow the given instructions	100	60	48	29	11	7	4	2	3	2
	I have acquired the skill to give scientific explanation on why there is a colour change if reducing sugars are present	86	52	56	34	17	10	5	3	2	1
Experimenting	I have acquired the skill to follow the appropriate procedure	102	61	53	32	10	6	1	1	0	0
	I have acquired the precautional skills of adding the right volume of benedict solution to the sample solution	90	54	54	33	16	10	4	2	2	1
	I have acquired the skill to use the Bunsen burner appropriately	99	60	54	33	10	6	3	9	0	0
	I have acquired the skill to perform the procedure on the experiment on solid food samples	101	61	49	30	10	6	2	1	3	2
	I have acquired the skill to use a hot water bath appropriately	103	62	48	29	10	6	3	2	2	1
	I have acquired the skill to perform the procedure of the experiment on powder food samples	106	64	49	30	7	4	3	2	1	1
	Average	**87**	**52**	**54**	**33**	**19**	**11**	**4**	**3**	**2**	**1**

Appendix I: Responses by teachers on the learners' developed appropriate SPS during a practical test on reducing sugars when using the MSL kits

Science process skills	Statements	Strongly agree		Agree		Not sure		Disagree		Strongly Disagree	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
OBSERVATION	learners have acquired the skill to identify the colour changes	10	77	3	23	0	0	0	0	0	0
	learners have acquired the skill to describe what is seen	11	85	2	15	0	0	0	0	0	0
MEASURING	Learners have acquired the skill to measure the right volume of benedict solution	7	54	5	39	1	8	0	0	0	0
	Learners have acquired the skill to measure the right volume of the food sample	7	54	5	39	0	0	1	8	0	0
CLASSIFY	Learners have acquired the skill to classify carbohydrates as monosaccharides, disaccharides and polysaccharides	6	46	3	23	4	31	0	0	0	0
	Learners have acquired the skill to categorise carbohydrates as either reducing or non-reducing sugars or starch	4	31	5	39	4	31	0	0	0	0

INFERENCE	Learners have acquired the skill to identify reducing sugars and non-reducing sugars after the experiment	8	62	2	15	3	23	0	0	0	0
	Learners have acquired the skill to draw the conclusion if the given food sample is a reducing sugar or not	7	54	2	15	4	31	0	0	0	0
PREDICT	Learners have acquired the skill to predict the outcome if reducing sugars are present or not	8	62	5	39	0	0	0	0	0	0
COMMUNICATION	Learners have acquired the skill to describe the findings after the experiment on reducing sugars	8	62	5	39	0	0	0	0	0	0
	Learners have acquired the skill to follow the given instructions	8	62	5	39	0	0	0	0	0	0
	Learners have acquired the skill to give scientific explanation on why there is a colour change if reducing sugars are present	7	54	5	39	1	8	0	0	0	0
EXPERIMENT	Learners have acquired the skill to follow the appropriate procedure	8	62	5	39	1	8	0	0	0	0
	Learners have acquired	7	46	7	54	0	0	0	0	0	0

	the precautional skills of adding the right volume of benedict solution to the sample solution										
	Learners have acquired the skill to use the Bunsen burner appropriately	6	46	7	54	0	0	0	0	0	0
	Learners have acquired the skill to use a hot water bath appropriately	8	62	5	39	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on solid food samples	7	54	6	46	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on powder food sample	7	54	6	46	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on the liquid sample	9	69	4	31	0	0	0	0	0	0
	Average	**8**	**58**	**5**	**35**	**1**	**7**	**0**	**0**	**0**	**0**

Appendix J: Observation ratings on the acquisition of SPS in learners during the practical test on reducing sugars when using the MSL kits

SCIENCE PROCESS SKILLS	STATEMENTS	Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
OBSERVATION	Learners have acquired the skill to identify the colour changes	14	100	0	0	0	0	0	0	0	0
	Learners have acquired the skill to describe what is seen	12	86	2	14	0	0	0	0	0	0
MEASURING	Learners have acquired the skill to measure the right volume of benedict solution	7	50	6	43	1	7	0	0	0	0
	Learners have acquired the skill to measure the right volume of the food sample	7	50	6	43	1	7	0	0	0	0
CLASSIFYING	Learners have acquired the skill to classify carbohydrates as monosaccharides, disaccharides, and polysaccharides	4	29	4	29	6	43	0	0	0	0
	Learners have acquired the skill to categorise carbohydrates as either reducing sugars or non-reducing sugars or starch	0	0	7	50	7	50	0	0	0	0
INFERENCE	Learners have acquired the skill to identify reducing sugars and non-reducing sugars after the experiment	9	64	5	36	0	0	0	0	0	0
	Learners have acquired the skill to draw the conclusion if the given food sample is a reducing sugar or not	9	64	5	36	0	0	0	0	0	0
PREDICT	Learners have acquired the skill to predict the outcome if reducing sugars are present or not	4	29	4	29	6	43	0	0	0	0

COMMUNICATION	Learners have acquired the skill to describe the findings after the experiment on reducing sugars	11	79	3	21	0	0	0	0	0	0
	Learners have acquired the skill to follow the given instructions	6	43	5	36	3	21	0	0	0	0
	Learners have acquired the skill to give scientific explanation on why there is a colour change if reducing sugars are present	3	21	4	29	5	36	2	14	0	0
EXPERIMENT	Learners have acquired the skill to follow the appropriate procedure	7	50	7	50	0	0	0	0	0	0
	Learners have acquired the precautional skills of adding the right volume of benedict solution to sample solution	5	36	8	57	1	7	0	0	0	0
	Learners have acquired the skill to use the Bunsen burner appropriately	5	36	9	64	0	0	0	0	0	0
	Learners have acquired the skill to use a hot water bath appropriately	9	64	5	36	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on solid food samples	6	43	8	57	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on powder food samples	6	43	8	57	0	0	0	0	0	0
	Learners have acquired the skill to perform the procedure of the experiment on liquid food samples	6	43	8	57	0	0	0	0	0	0
	Average	**7**	**49**	**5**	**39**	**2**	**11**	**2**	**1**	**0**	**0**

Appendix K: Responses by learners on the acquisition of the appropriate knowledge during a practical test on reducing sugars when using the MSL kits

	Strongly agree		Agree		Not sure		Disagree		Strongly disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
I have acquired the knowledge to understand what reducing sugars are	40	24	65	39	53	32	6	4	2	1
I have acquired the knowledge to describe the procedure involved in this practical	72	43	69	42	21	13	2	1	2	1
I have acquired the knowledge to explain the procedures involved in this practical	67	40	61	37	32	19	6	4	0	0
I have acquired the knowledge to explain the measure of the required volume of the reagent and the food sample	99	60	53	32	11	7	2	1	1	1
I have acquired the knowledge to describe the colour changes in this practical	79	48	60	36	18	11	6	4	3	2
I have acquired the knowledge to rank the proceedings of the practical	79	48	55	33	22	13	8	5	2	1
I have acquired the knowledge to differentiate reducing sugars from non-reducing sugars	103	62	47	28	10	6	2	1	4	2
I have acquired the knowledge to make the conclusion from the observations of the experiment	101	61	57	34	6	4	1	1	1	1
Average	**80**	**48**	**58**	**35**	**22**	**13**	**4**	**3**	**2**	**1**

Appendix L: Responses by teachers on the learners' acquisition of appropriate knowledge during a practical test on reducing sugars when using the MSL kits.

STATEMENTS	Strongly agree		Agree		Not sure		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Learners have acquired the knowledge to understand what reducing sugars are	1	7	8	62	4	31	0	0	0	0
Learners have acquired the knowledge to describe the procedure involved in this practical	5	39	6	46	2	15	0	0	0	0
Learners have acquired the knowledge to explain the procedures involved in this practical	9	69	3	23	1	8	0	0	0	0
Learners have acquired the knowledge to measure of the required volume of the reagent and the food sample	9	69	3	23	1	8	0	0	0	0
Learners have acquired the knowledge to describe the colour changes in this practical	6	46	6	46	1	8	0	0	0	0
Learners have acquired the knowledge to rank the proceedings of the practical	7	54	4	31	2	15	0	0	0	0
Learners have acquired the knowledge to differentiate reducing sugars from non-reducing sugars	7	54	5	39	1	8	0	0	0	0
Learners have acquired the knowledge to make the conclusion from the observation of the experiment	7	54	5	39	1	8	0	0	0	0
AVERAGE	**6**	**49**	**5**	**38**	**2**	**13**	**0**	**0**	**0**	**0**

Appendix M: Observation on the acquisition of the appropriate knowledge by learners during a practical test on reducing sugars when using the MSL kits.

STATEMENTS	Strongly agree		Agree		Not sure		Disagree		Strongly disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
learners have acquired the knowledge to understand what reducing sugars are	1	7	7	50	6	43	0	0	0	0
Learners have acquired the knowledge to describe the procedure involved in this practical	4	29	9	64	1	7	0	0	0	0
Learners have acquired the knowledge to explain the procedure involved in this practical	9	64	5	36	0	0	0	0	0	0
Learners have acquired the knowledge to explain the measure of the required volume of the reagent and the food sample	13	93	1	7	0	0	0	0	0	0
Learners have acquired the knowledge to describe the colour changes in this practical	5	36	8	57	1	7	0	0	0	0
Learners have acquired the knowledge to rank the proceedings of the practical	8	57	4	29	2	14	0	0	0	0
Learners have acquired the knowledge to differentiate reducing sugars from non-reducing sugars	9	64	5	36	0	0	0	0	0	0
Learners have acquired the knowledge to make the conclusions from the observation of the experiment	13	93	1	7	0	0	0	0	0	0
AVERAGE	**8**	**55**	**5**	**36**	**1**	**9**	**0**	**0**	**0**	**0**

Appendix N: Responses by learners on the extent of stimulation during a practical test on reducing sugars when using the MSL kits.

Statements	strongly agree		Agree		Not sure		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
I have stimulated to pursue a biological career dealing with reducing sugars	80	48	52	31	18	11	13	8	3	2
I have been stimulated to develop a positive attitude towards experiments and reducing sugars	104	63	50	30	6	4	3	2	3	2
I have been stimulated to develop an interest to work hard in biology	96	58	50	30	15	9	5	3	0	0
I have been stimulated to acquire a detailed understanding of reducing sugars	71	43	70	42	22	13	3	2	0	0
I have been stimulated to develop curiosity to learn more on reducing sugars	102	61	51	31	10	6	2	1	2	1
I have been stimulated to develop creativity on carrying out practical test on reducing sugars	60	36	72	43	23	14	9	5	2	1
I have been stimulated to eradicate superstition	89	54	59	36	11	7	5	3	2	1
Average	**86**	**52**	**58**	**35**	**15**	**9**	**6**	**3**	**2**	**1**

Appendix O: Ratings by teachers on the extent of stimulation by learners during a practical test on reducing sugars when using the MSL kits.

STATEMENTS	Strongly agree		Agree		Not sure		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Learners have been stimulated to pursue a biological career dealing with reducing sugars	7	54	3	23	3	23	0	0	0	0
Learners have been stimulated to develop a positive attitude towards experiments and reducing sugars	8	62	4	31	1	8	0	0	0	0
Learners have been stimulated to develop an interest to work hard in Biology	5	39	4	31	1	8	2	15	1	8
Learners have been stimulated to acquire a detailed understanding of reducing sugars	8	62	3	23	2	15	0	0	0	0
Learners have been stimulated to develop curiosity to learn more on reducing sugars	7	54	6	46	0	0	0	0	0	0
Learners have been stimulated to develop creativity on carrying out practical test on reducing sugars	5	39	5	39	3	23	0	0	0	0
Learners have been stimulated to eradicate superstition	6	46	4	31	2	15	1	8	0	0
AVERAGE	**7**	**51**	**4**	**32**	**2**	**13**	**0**	**3**	**0**	**1**

Appendix P: Observation ratings on the extent of stimulation by learners during a practical test on reducing sugars when using the MSL kits.

STATEMENTS	Strongly Agree		Agree		Not sure		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Learners have been stimulated to pursue a biological career dealing with reducing sugars	4	29	4	29	6	42	0	0	0	0
L earners have been stimulated to develop a positive attitude towards experiments and reducing sugars	6	43	8	57	0	0	0	0	0	0
Learners have been stimulated to develop an interest to work hard in biology	3	21	9	64	2	14	0	0	0	0
Learners have been stimulated to acquire a detailed understanding of reducing sugars	4	29	8	57	2	14	0	0	0	0
Learners have been stimulated to develop curiosity to learn more on reducing sugars	5	36	7	50	1	7	1	7	0	0
Learners have been stimulated to develop creativity on carrying out practical test on reducing sugars	3	21	10	71	0	0	1	7	0	0
Learners have been stimulated to eradicate superstition	4	29	8	57	2	14	0	0	0	0
AVERAGE	**4**	**30**	**8**	**55**	**2**	**13**	**0**	**2**	**0**	**0**