Investigating the opportunities for developing Science Process Skills in learners: A study of food tests practical work

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DECLARATION

I, **Portia Nkabinde,** hereby declare that this research report titled, 'Investigating the opportunities for developing Science Process Skills in learners: A Study of food tests practical work' is my original work. It is submitted for the degree of Master of Education at the University of Witwatersrand, South Africa. I affirm that all sources of information have been properly acknowledged and cited. This work has not been submitted previously, in whole or in part, for any other academic qualification or publication.

17 March 2025

DEDICATION

I am indebted to my family for their unwavering love and moral support which they have consistently rendered to me, even from miles away, not only during the completion of this study but throughout my entire existence. I dedicate this work with immense gratitude and love: To my loving parents, Busisiwe Beatrice Ngubo and Eric Simangaliso Nkabinde; my incredible siblings, Sifiso, Bongiwe and Thandanani Nkabinde. Your love, prayers and encouragement have carried me through every challenge and triumph. Despite the distance, your presence has always been felt in my heart, reminding me that I am never alone in the pursuit of academic excellence.

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GLOSSARY

Abbreviations	Explanation
AAAS	American Association for the Advancement of Science
CAPS	Curriculum Assessment Policy Statement
DBE	Department of Education
FET	Further Education Training
GDE	Gauteng Department of Education
PCK	Pedagogical Content Knowledge
SAPA	Science A Process Approach
SCORE	Science Community Representing Education

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Abstract

Science process skills are fundamentally crucial in the context of science education. Teachers play an important role for creating opportunities for learners to develop their science process skills. This study aimed to investigate the opportunities for developing science process skills in learners during food tests practical work, a topic covered in Grade 10 Life Sciences. One school was purposively sampled. The study sought to answer one main question and three sub-questions. Participants of this study included one Life Sciences teacher who facilitated one practical lesson of four food tests investigations to a class of 17 Grade 10 Life Sciences learners. A qualitative method approach was used, and it allowed for diverse data sources to ensure validity and reliability. The data sources used were document analyses, video recording of the practical lesson and the teacher's interview. Science process skills approach, constructivism and pedagogical content knowledge were used as theoretical frameworks to underpin the study. The analysis of the Curriculum Assessment Policy Statement (CAPS) indicated that there are ten science process skills that should be developed in learners through doing Life Sciences. These science process skills are observing, measuring, classifying, communicating, controlling variables, hypothesising, experimentation and data interpreting. Of these science process skills seven can be developed through food tests practical work. In this study minimal opportunities were provided for developing science process skills in learners during food tests practical work. This study showed that when practical work is not well structured as a scientific inquiry-based investigation, there will be limited opportunities for developing science process skills in learners. The study provided insights into the extent in which practical work as a teaching and learning strategy could be used to develop science process skills in learners.

Key words: science process skills, practical work, demonstration, food test

Chapter 1

Introduction to the study

1.1 Introduction

This chapter provides a rationale for the study by examining the background of the study and a focus on the research problem and the research questions. The chapter outlines the study's significance and limitations.

1.2 Background

For many years, practical work as an instructional strategy, has been an integral part of science teaching and learning (Abrahams & Millar, 2008) because it bridges the gap between theoretical knowledge and real-world application. Through practical work, learners are not only able to observe scientific phenomena but also offers opportunities for the development of science process skills such as observing, measuring, classifying, hypothesizing, experimenting, analysing, and drawing conclusions. Practical work as a teaching and learning strategy is crucial for not only helping learners grasp key concepts and scientific inquiry but to develop science process skills (Ausubel, 1968). Practical work can be achieved through a variety of activities such as experiments, laboratory work, research investigations, outdoor field work, and collaborative projects (Kibirige & Maponya, 2021). Incorporating practical work in the classroom has multiple advantages. A study conducted by Falemu and Akinwumi (2021) examined the impact of biology practical work on academic performance of secondary school learners of Ekiti state in Nigeria. The findings revealed that incorporating practical work significantly enhanced learners' understanding of biological concepts and increased their academic performance as these activities allowed them to link theoretical concepts with practical work.

The Science A Process Approach (SAPA), an innovative science education curriculum developed in the 1960s by the American Association for the Advancement of Science (AAAS), introduced the concept of 'science process skills' to shift the focus of science from a knowledge based subject to a curriculum that emphasizes skills (De Jager, 2001). Research findings and the National Science Education Standards (National Research Council, 2000) have advocated science process skills for over 30 years. This study sought to investigate the opportunities for developing science process skills in learners during food tests practical work in Life Sciences. The current study drew from how the teacher facilitated the food tests practical work. This topic is taught in Grade 10 and was chosen for this study because it could enable the teacher to create numerous opportunities to develop several science process skills.

In the South African context, De Jager and Ferreira's (2003) study was prompted by the lack of science process skills in biology learners in the Gauteng Province. Although, the development of science process skills was a required outcome of Curriculum 2005, it was often overlooked in South African classrooms. The authors found that the factors hindering the development of science process skills were teacher-centred approach, insufficient resources, curriculum constraints, assessment practices and teacher preparedness (De Jager & Ferreira, 2003). These findings highlighted the need for changes encompassing a revised curriculum, teacher professional development and better resources to foster active learning and the development of science process skills.

The South African Curriculum Assessment Policy Statement (CAPS, DBE, 2011) states that learners are expected to design and conduct practical work by investigating phenomena in Life Sciences but also develop science process skills. In teaching and learning science several key skills should be developed, including measuring, observing, classifying, inferring, predicting, communicating, interpreting data, hypothesizing, experimenting and formulating models (Ango, 2002). The teacher's role is crucial in offering learners numerous opportunities to develop these science process skills.

Ambross et al., (2014) research aimed to investigate the views of four primary school Natural Sciences teachers regarding the implementation and development of science process skills within the classroom of a disadvantaged urban primary school in South Africa. The authors found that the development and implementation of science process skills were significantly impacted by the teacher's level of confidence and comprehension of these skills, which were, in turn, linked to their current and past experiences with science process skills. Similar research conducted by Molefe and Aubin (2021) examined the views of pre-service science teachers on science process skills and discovered that while these teachers were able to develop their observing skills, they were unable to effectively connect observing and communication to formulate a research question. Similar difficulties were also evident in designing experiments. While the teachers were able to link science process skills with forming hypotheses, they faced difficulties in linking other science process skills such as making inferences.

It is apparent that a teacher can often hinder the development of science process skills. Teachers often fall short in possessing the necessary expertise in the science process skills due to inadequate training. With that said, teachers must possess expertise in science process skills and in developing them in learners as well. It is crucial that learners develop these skills as they are essential for understanding scientific concepts and achieving success in academic pursuits. Therefore, it was imperative to conduct this study which investigated the opportunities for developing science process skills in learners during food tests practical work.

The current study focused on food tests practical work experiments conducted in Grade 10 Life Sciences. Food tests are laboratory experiments used to identify the presence of organic molecules such as carbohydrates (glucose and starch), lipids and proteins in food samples. These experiments require a laboratory set up for learners to control and manipulate variables, thereby enabling the collection of data and the drawing of conclusions. This topic will provide the learners multiple opportunities to develop their science process skills. The Specific Aim 2 of CAPS stipulates that learners must be able to plan and carry out investigations. Furthermore, they ought to use a specific set of skills when conducting practical work (DBE, 2011). In the current study, the selected topic namely food tests fall under ‘Organic Compounds’ and serves as a foundation for future topics to be explored in Grades 11 and 12 within the Life Sciences curriculum. For example, learners need to understand that even though both glucose and starch are carbohydrates they have different structures and functions, so it is essential to test them individually to confirm this difference. This will be useful in Grade 11, when they look into the topic of photosynthesis in greater detail. Another example, proteins are introduced in Grade 10 where learners are taught that amino acids are monomers that make up proteins. Later in Grade 12, learners delve into the details of protein synthesis in more depth.

1.3 Research problem

According to CAPS (DBE 2011) studying Life Sciences should enable learners to develop scientific skills which enable them to view the world through a scientific lens. Furthermore, one of the aims in Life Science incorporates science process skills which links to doing practical work.

Teachers in some South African schools lack confidence in using practical work to teach science, as reported by Kibirige and Hodi (2013). As a result, they often fall back on more teacher-centred approaches, such as lecturing, show and tell and chalk-and-talk. This is because teachers lack the skills, even in schools have well-resourced laboratories (Muwanga-Zake, 2008).

Several studies have highlighted the value of practical work and science process skills in improving learners’ understanding of science concepts. For example, Festile (2017) found that practical work led to improved learner performance and strengthened the overall teaching and learning in Natural Sciences. Similarly, Kibirige et al. (2014) showed that Grade 10 learners in South Africa performed significantly better when practical work was used to teach heat and temperature. While Kazeni (2008) developed and validated an instrument for assessing integrated science process skills among high school learners South Africa. Maraisane, Jita and Jita (2024) investigated the extent to which early childhood teachers engaged in science process skills when teaching science concepts to very young learners. While these studies collectively acknowledge the importance of practical work and science process skills in science education, they do not address the extent in which practical work could provide opportunities for the development of science process skills in learners, a knowledge gap this research aimed to address.

1.4 Research question

The main objective of the investigation centres around the research question that is:

How does practical work in food tests provide the opportunities to develop science process skills in learners?

In order to address the main research question the following sub-questions were answered:

1. Which science process skills can be developed through food tests practical work?
2. How were the food tests practical work carried out in this study?
3. Which science process skills, if any, were assessed in the practical assessment task?

1.5 Rationale

Ango (2002) stated that fundamental aspect of scientific expertise involves having a solid understanding of science process skills. To achieve expertise, learners require instruction in the principles of scientific investigation, which included the development of science process skills. The author further adds that learners can be given the opportunity to observe, handle apparatus and explore. Teachers tend to focus more on the content knowledge.

Food tests practical work is particularly suitable for investigating the development of science process skills in Life Sciences. This topic allows learners to develop a wide range of these skills. In conducting tests for starch, glucose, proteins and lipids, learners can observe colour changes, classify results according to the presence and absence of nutrients, and communicate their findings through written laboratory reports. At the same time, this topic fosters the development of more complex skills such as formulating hypotheses, designing of the experiments through selection of suitable reagents and controls, and the interpretation of data to draw conclusions about biochemical molecules. Food tests practical work offers an authentic context that should provide the opportunities for learners to develop their science process skills.

Often teachers do not provide opportunities for the development of science process skills while carrying out practical work. As a result, teachers demonstrate the practical work and use it as a teaching strategy to strengthen content knowledge. This study focused on opportunities provided to develop science process skills during food tests practical work. Food tests fall under the topic of 'Organic Compounds' in section of 'The Chemistry of Life' in the Grade 10 Life Sciences curriculum. In this study the researcher will be analysing the learners' results of the practical assessment task. The practical assessment task in Life Sciences is written to formally to assess learners' ability to apply scientific knowledge and demonstrate science process skills.

1.6 Significance

This study was a very small study which was meant to be carried out in six months. However, the study's results are expected to provide insights on which science process skills can be developed through food tests practical work and how those skills can be developed in learners. These insights can be beneficial for subject specialists, policymakers and other stakeholders in the Department of Education as they could provide new insights into implementing practical work, with the focus on science process skills, in schools.

Furthermore, it is anticipated that the study's results will enhance the existing body of research, offer recommendations, and provide valuable information for additional and future academic studies as other researchers could build on the study's gaps and limitations.

1.7 Scope and limitations of the study

According to Msabila and Nalaila (2013), study limitations encompass potential challenges anticipated or encountered by the researcher. This study could not be conducted without limitations. Since there was one participant sampled for this research, from one high school in Johannesburg East District in Gauteng, the number of the participant was small. Therefore, the findings from this study cannot be generalised to other schools in Gauteng and South Africa at large. The results of this study need to be further verified and validated through further research.

1.8 Conclusion

This chapter provided the rationale for the study by highlighting the research problem, outlining the background, as well as research questions that guided this study. The next chapter presented the theoretical framework and reviewed the literature relevant to this study.

Chapter 2

Literature Review

2.1 Introduction

The previous chapter examined the background of the research. This chapter will examine literature focusing primarily on the subject of science process skills that can be developed during practical work. It will then delve into the findings and insights of existing research on practical work in teaching and learning. Lastly, it will examine theoretical frameworks that form the basis of this study.

2.2 Science process skills that can be developed during practical work

2.2.1 Importance of science process skills

Various studies have found that incorporating practical work in a science class prepares learners with practical skills through hands-on learning, which is argued to promote their knowledge, acquisition of skills as well as improve their performance (Apeadido et al., 2024). Shana and Abulibdeh (2020) cite Jakeways (1986) to state that integrating practical work is essential to science education. Furthermore, it significantly contributes to learners' understanding of scientific knowledge and development of skills.

It is indicated that the learning opportunities that come with practical work encompass hands-on and minds-on learning, whereby learners have the opportunity to practice and develop various process skills (Chala, 2019). In the same light, it is noted that some of the outcomes of practical work include the ability to develop inquiry and technical skills, which further increases motivation, and allows learners to be accustomed to analysing problems (Anwar, 2023). Chala (2019) states that the skills include learners being able to hypothesise, observe, interpret, predict, solve problems, communicate, as well as being able to evaluate and draw conclusions. One of the current study's objectives, is to investigate which of the science process skills can be developed during food tests practical work.

According to Dela Cruz (2015) learning sciences should develop learners as inquirers, scientifically literate, caring and responsible individuals who will think critically and creatively when solving problems and making decisions about aspects affecting themselves, others and their social and natural environments. It is further postulated that the development of science process skills is an interdisciplinary matter (Hodosyova et al., 2015). Topics of all science subjects overlap each other in common science concepts which are energy, properties of matter, particle structure of matter, motion, change and living systems (Hodosyova et al., 2015). These concepts associate subjects thematically and they are the source of creation and development of interdisciplinary relations (Hodosyova et al., 2015).

In addition, Jirout and Zimmerman (2015) argue that, even though some mechanisms of science learning such as curiosity, asking questions, and exploration, may seem to develop spontaneously in children, all science process skills require support. This support can also be in the form of scaffolding, and instruction to mature into the sophisticated process skills seen in scientifically literate adults and trained scientists (Jirout & Zimmerman, 2015). The current study explores the teacher's role in creating opportunities for learners to develop science process skills, which typically do not develop spontaneously.

2.2.2 Defining science process skills

Ambross et al., (2014) cite the 2002 South African curriculum framework, National Curriculum Statement NCS (DoE, 2002), to state that science process skills refer to learners' cognitive activity of creating meaning and structure from new information and experiences, in other words, learning strategies used in the process of understanding a new situation or in its presentation. They are essential in enabling learners to develop an understanding of, and the ability to, identify and use relevant science evidence in solving problems and making decisions (Harlen, 1999 cited in Ambross et al., 2014). A science investigation puts emphasis on the use of the scientific method in performing an investigation by experimentation (learning that is inquiry based) to develop critical thinking and science process skills of the learner (Dela Cruz, 2015). The current study's relevance necessitated an examination of the extent to which practical work provides the opportunities to develop science process skills in learners.

Science process skills refer to multifaceted abilities that scientists commonly use when they conduct scientific investigations into a series of learning processes (Rini & Aldila, 2023). They are also defined as abilities reflecting how scientists act and think (Tan et al., 2020). Rini and Aldila (2023) further cite Gunawan et al (2019), who state that science process skills refer to behaviour that encourages skills in knowledge acquisition (Rini & Aldila, 2023). They are skills that scientists use for analysing or exploring an issue, problem, question, or scientific phenomena that happened during the learning process (Idris at al., 2022). According to Idris et al., (2022), in science experiments or practical work, science process skills are essential skills. In agreement, Bahtiar and Dukomalamo (2019) note that science process skills are necessary for a deep understanding of science. This statement is supported by Gultepe (2016), who also held that one of the fundamental skills that curricula should aim for learners is to attain science process skills.

Rini and Aldila (2023) also point out that science process skills are one of the critical skills needed in this century. Science process skills are process thinking skills using scientific processes and approaches. Scientific process skills are very important for every individual, because they are almost always used in everyday life (Mutlu, 2020). Science process skills allow learners to employ scientific knowledge in everyday situations and prepare future scientists with scientific literacy (Bahtiar & Dukomalamo, 2019). It is important that every learner has a solid understanding of science process skills as this helps them in employing scientific techniques to develop and grow their knowledge in science (Bahtiar & Dukomalamo, 2019). In the same light, Darmaji et al., (2019) explains that science process skills are said to provide learners with a meaningful learning experience as they help them in achieving high-level thinking.

According to Bahtiar and Dukomalamo (2019), for learners to be able to acquire knowledge on their own in the future, they must possess basic science process skills. Basic process skills are those skills that a learner must master first, before they master integrated process skills (Darmaji et al., 2019) It is further noted that a learner who does not have basic science skills, for example, observation skills, will not be able to obtain information and discover what the problem that needs to be solved is (Darmaji, et al., 2019). These basic science process skills are integrated together when scientists design and carry out experiments or in everyday life when one carries out fair test experiments. The make-up of science process skills involves various basic and complex abilities that are divided into two categories, which are basic process skills as well as integrated process skills (Idris et al., 2022).

The American Association for the Advancement of Science (AAAS, 1967) originally listed 12 skills as science process skills. In 1993, the association subsequently divided the science process skills into 15 distinct activities: observing, measuring, classifying, communicating, predicting, inferring, working with numbers, utilising space/time relationships, questioning, controlling variables, hypothesizing, defining operationally, formulating models, designing experiments, and interpreting data (Gizaw & Sota, 2023). The AAAS (1967) classified science process skills in two categories: basic and integrated science process skills. The basic science process skills are skills at a lower level of complexity on the other hand, integrated science process skills are at a higher level (Gizaw & Sota, 2023). It is argued that learners' integrated science process skills cannot be easily trained and are more challenging to improve (Sulistri, 2019). The current study will focus on ten of the science process skills proposed by Chiappetta and Koballa (2002). The descriptions of the science process skills are presented in Table 1 below.

Table 1 Science process skill and descriptions

Basic science process skills	
Observing	Objects and events are observed when one uses all their five senses, and this is how learning about the world occurs (Sahnaz, Harlita & Ramli, 2018).
Measuring	Measuring refers to quantitatively showing the number of objects or substances (Inayah, Ristanto, Sigit, & Miarsyah, 2020)
Classifying	This refers to the categorisation or ordering of objects or events into groups according to a particular criterion or based on specific (Dela Cruz, 2015).
Inferring	Making inferences refers to using available evidence to describe, understand, or making pre-conclusion about something that has happened or something that has been observed (Rani, 2017).
Predicting	Making a prediction is stating the outcome of a future event using a theme or pattern from the information available (Inayah, Ristanto, Sigit & Miarsyah 2020).
Communication	Communication is the use of words or graphic symbols to describe an action, object or event (Dela Cruz, 2015)
Integrated science process skills	
Making hypothesis	Making a hypothesis refers to stating what the outcome should be expected in an experiment (Dela Cruz, 2015)
Controlling variables	The ability to identify and control variables in thus an important skill in practical work as this allows the learner to see changes in variables that are linked to other variables (Darmaji et al., 2019).
Experimenting	Inayah et al. (2020) further adds that this skill involves testing hypotheses as well as manipulating and controlling independent variables and then watching how those changes affect the dependent variable.
Interpreting data	This skill refers to the ability to explain results, conclusions, or hypotheses from available data that have shown using graphs or tables (Inayah et al., 2020).

2.2.3 Developing science process skills in learners

It is noted that science process skills can be learned if taught in the classroom when teachers also use proven teaching methods, such as practical work (Dela Cruz, 2015). These skills can be reserved for future use if lessons are founded on science investigations and practiced over time (Dela Cruz, 2015). Sulistri (2019) points out that the use of practical methods can contribute to improving learners' science process skills, both basic and integrated, in that practical work also improves cognitive, psychomotor, as well as affective skills. Hence the significance of the current study in that it aims to investigate the development of science process skills as it may have a significant influence on learners' academic development.

Several research studies confirm the existence of a positive correlation between science process skills and academic achievement (Aktamis & Ergin, 2008). Therefore, there is need for multiple and consistent practical work to help in developing science process skills especially integrated science process skills, as this gives learners the necessary tools to interpret their observations and design experiments to test hypotheses (Ongowo, 2017).

In this light, Dela Cruz (2015) states that learning sciences ought to advance learners as curious, scientifically literate, caring and responsible people who can critically and creatively think when it comes to problem-solving and decision-making. Researchers have proposed that the development of science process skills in students is facilitated by several approaches; the first being the incorporation of science process skills into the curriculum, the second is implementing science process skills in classroom instruction, the third is incorporating science process skills into the assessment, the fourth is utilising teaching methods that encourage the application of science process skills and the fifth is explicitly teaching of science process skills (Gizaw & Sota, 2023). These approaches were relevant to the current study, especially the aspect of incorporating science process skills in CAPS (DBE, 2011), the extent in which the teacher provides opportunities to develop science process skills during the food tests practical work, and the inclusion of science process skills in the assessment.

2.3 Practical work in teaching and learning

2.3.1 Defining practical work

Jenkins (2013) stated that scientists' attempts to increase pupils' intellectual rigor in the late 19th century by putting them in real-world settings that connect them to the natural world. These initiatives made practical work a recognised instructional strategy. Assuming that generalisations and patterns are inherent in all scientific inquiries, there was a strong emphasis on discovery learning through pattern recognition (Aubusson, 2011). The instructional strategies that were used improved the importance of practical activity in the science teaching and learning process (Tsakeni, 2018). However, although there seemed to be benefits for this new way of teaching science, it has also been argued that practical work is simultaneously underused and overused (Oliveira & Bonito, 2023). Therefore, it is important to fully understand what practical work is, what is means, and how it can be appropriately used to benefit the learners.

Practical work is any activity in which the student observes or works with actual or virtual objects and materials (Antwi et al., 2021). Constantinou and Fotou (2020) add that practical work can be defined as an instructional tool that is thought to be beneficial in fostering learning as well as making the science lesson more enjoyable. It can also be defined as learning experiences whereby learners interact with material (Chala, 2019). In science education, practical work has become increasingly important, especially since the 60s (Oliveira & Bonito, 2023). According to Millar et al., (2002) practical work also refers to laboratory activities that include lecturing, group experiments and teacher demonstrations, all of which involve learners in hands-on handling and observing of real objects and materials.

The fundamental principle of learning science, practical work cannot be separated from learning chemistry, including biochemistry (Anwar, 2023). Practical work is pointed out to be very critical for teaching and learning process in school science and it is further argued that good quality of application of practical work is helpful in the development of learners' understanding of scientific concepts and processes (Chala, 2019). Anwar (2023) further adds on to this by pointing out that learners can also grow a deeper understanding of concepts while also practicing their skill to explain in writing as well as verbally. Teachers and academics have always valued practical work as a method of instruction. It is undeniable that its inclusion in the Life Sciences and Biology curriculum in both secondary and university level has been beneficial.

2.3.2 Demonstrations as a form of practical work

Demircioglu and Yadigaroglu (2011) describe demonstration as either laboratory or simple hands-on experiments. According to El Rabadi (2013) state that demonstration comprises a series of procedures carried out by learners using laboratory equipment and materials under the supervision of teachers to gather specific information about the studied phenomenon. According to Hirça (2013), hands-on experiments involve procedures conducted by teachers or students, typically under the instructor's guidance, and can be implemented without costly equipment or laboratory facilities; instead, they can be carried out using accessible materials and resources.

There are several advantages of using demonstrations in the classroom. Research by Basheer et al., (2016) revealed that exposing learners to demonstrations significantly enhanced their comprehension in science, fostered advanced thinking skills and enabled learners to think more creatively. These findings align with Sweeder and Jeffery's (2013) observation that well-planned demonstrations, when effectively incorporated, have the potential to significantly contribute to learners achieving a comprehensive grasp of scientific concepts.

Although there are benefits of using demonstrations in the classrooms there are challenges as well. A Nambian study was conducted by Kandjeo-Marenga (2011) on the teaching and learning implications of teacher demonstrations and group experiments for practical work in biology at secondary schools. The study found that teacher demonstrations developed a few science process skills whereas the group experiments provided more opportunities for the development of more science process skills in learners.

2.3.3 The role of practical work

Millar (2004) points out that practical work is extensively and regularly used in science education in English secondary schools. It is further mentioned that the possible reason for this, is that the belief by many science teachers is that frequently using practical work seems to be a necessary part of what being ‘a science teacher’ entails (Millar, 2004). In England, it is cited that teachers believe that practical work seems like it is the ‘natural’ and ‘right’ thing to do when teaching science (Abrahams & Reiss, 2012). This means that a lot of educators view the use of practical lessons as the standard formula for science education. Indeed, there is a common belief amongst many teachers that using practical work may potentially motivate learners towards the study of science (Abrahams & Reiss, 2012). It is then argued that this approach could be risky and less effective in that religiously and routinely using practical lessons may result in no critical assessments to see if this method is effective for all learning outcomes. The aspect of using practical work as the ‘right’ thing to do relates to this study’s objective which is to investigate what actually happens during practical work, moreover whether or not if there are any opportunities for the development of sciences process skills.

Many studies have showed that there are many advantages that can be associated with practical work (Shana & Abulibdeh, 2020). These advantages include the development of laboratory skills and scientific knowledge, as well as understanding theories and specific concepts within science. It is further argued that practical work could increase learners understanding, line of reasoning, and confidence (Anwar et al., 2018). It enables learners to develop their knowledge base and comprehension of the world that exists around them, by using concepts, theories and models (Kambaila et al., 2019). In the same light, it is noted that practical and experimental tasks appeal as a way of enabling learners to learn with understanding and, while simultaneously, participate in a process of constructing knowledge using science (Shana & Abulibdeh, 2020). Moreover, Anwar et al. (2018) argued that the expectation of practical and experimental work is that it forms a bridge between theory with practice. It is noted that learners’ interpretations of the models being taught, used in explaining theory, can be tried and re-evaluated through such practical work, which further improves learners’ conceptual understanding science and the work they do (Chala, 2019).

2.3.4 International findings on the use of practical work

The United States of America has placed an emphasis on learning science while practically doing science, and laboratory activities in science classroom in secondary schools remains to be a crucial element of a solid curriculum (Boesdorfer & Livermore, 2018). It has been pointed out that in the United Kingdom, learners spend more time partaking in practical activities during science education compared to learners many other countries (Chala, 2019). A study conducted by Koirala et al., (2019) in Gorkha District Nepal, found that the use of practical approach in a science lesson assists learners in developing a clear understanding of scientific concepts compared to traditional methods of teaching.

In their study on the impact of practical work in science on academic performance in a Rwanda secondary school, Twahirwa and Twizeyimana (2020) found that practical work had a significant positive impact in the improvement of learners' performance in science. Another Rwandan study observed that when practical work is added in teaching and learning science, there is new knowledge generated, as well as the formation of meaning of theoretical concepts in science (Niyitanga et al., 2021). In the same light, in Nigeria, it was found that a method of teaching whereby both theory and practical work were incorporated as frequently as possible was more pleasing and advantageous to learners with regards to their academic achievement (Achor & Agambar, 2016). Similarly, another study conducted in kere Local Government Area of Ekiti State in Nigeria, found that biology practical activities raise learners' achievement in biology performance (Falemu & Akinwumi, 2021). Based on the above studies, authors have highlighted key features that made practical work yield positive results, such as skilled teachers, the quality of the laboratories and learners' attitudes towards the subject. On the other hand, findings indicated that insufficient training and policy governing the use of practical work combined with insufficient equipment and facilities hindered the use of practical work in teaching and learning.

The Science Community Representing Education (SCORE, 2008) states that there is evidence that practical education increases learners' sense of autonomy as they learn and further increases their motivation. In the same light, it is stated practical work has been able to encourage learners' positive attitudes and develop motivation for successful learning in science (Okam & Zakari, 2017). This finding is in line with a study conducted on a sample of 25 science lessons in English secondary schools that involving practical work, the study's findings revealed that practical work helped the lesson's direction by keeping learners' attention on the tasks and performing the hands-on work (Abrahams & Millar, 2008). However, practical work was shown to be less successful in helping those learners integrate theory and application in the lab and reflect on the facts they had gathered. With that said, authors suggested that teachers should pay more attention to the design of the practical work. In other words, teachers should design practical work activities that enable learners to link theoretical concepts with practical work. This aspect is very important to the current study as it will also explore to see if the practical handout given to the learners, provides any opportunities for the development of science process skills during practical work.

A study was conducted on the Impact of practical work experience on academic achievement in biology among by Nneji et al., (2024) in senior Secondary School learners in Yenagoa Metropolis. The study found that the academic achievement of learners in biology was significantly increased by practical work in contrast, to learners who were not exposed to practical work (Nneji et al., 2024). The authors went on to recommend that teachers should implement practical work at least once a week in both primary and high schools. These findings were supported by Chala (2019), who stated that there has been various research that has recognised that when leaners are taught science using practical work, there is evident improvement in their achievement and skills.

Considering this, Millar (2004) suggests that learners should be exposed to some background material on the topic of their investigation in order to excite their thoughts before beginning any actual work. Additionally, the task design should guide the learners' attempts to draw connections between the two knowledge domains. This can be attributed to the fact that, even though practical work is to some extent, an effective tool in getting the learners to remember the practical aspects of an experiment, the ideas behind the phenomena are rarely learned and even more so remembered later (Abrahams & Millar, 2008). The current study expands on previous research by analysing the extent in which the teacher provides the learners with the opportunities to develop science process skills.

Another argument in this light, is that science educators should receive training based on the most recent research findings to change their methods and devote more time and effort to thinking about how to relate scientific ideas to the natural world (Jokiranta, 2014). In Finland, this has not yet been properly investigated, but in places like England scientific education experts have long been fascinated by the effectiveness of practical work (Jokiranta, 2014).

2.3.5 Practical work in South Africa

According to Kibirige et al., (2014) whose study aim was establishing the impact that practical work has on the performance of learners in science, practical work has shown to have a significant and positive impact on learner performance in science (Kibirige et al., 2014). Additionally, Kazeni and Mkhwanazi (2020) found that it was clear that there was a positive attitude from participants when it came to practical work or what is also referred to as inquiry-based science education. Some of the cited benefits of practical work in science included learners' actively engaging in the learning process; the opportunity for both learners and teacher to make learning applicable in day-to-day experiences; learners being motivated to learn life sciences; as well as the improvement of learners' understanding and knowledge of abstract concepts in life science (Kazeni & Mkhwanazi, 2020). This can be argued to also relate to the findings on practical work in science education from international findings.

In exploring science teachers' perceptions of practical work in Mankweng Circuit, South Africa, Kibirige and Maponya (2021) found that most of the teachers who participated in their study often utilised narratives to teach practical work, which meant that learners memorise how to do experiments. Therefore, given that problem solving and critical thinking are some of the aims of practical work is science, such practices can be argued to be conflicting to teaching science for conceptual understanding. The findings of the study (Kibirige & Maponya, 2021) revealed that none of the participating teachers employed practical work as a method of teaching science process skills to learners and enabling the understanding of concepts in science. In the same light, data from Samaneka (2015) showed that there were schools in South Africa, that did not engage in real practical work, although practical exams are an instructed requirement of the Life Sciences CAPS document (DBE, 2011).

A study by Kibirige and Maponya (2021) found that even though it was a requirement to carry out practical work, as stated in the CAPS document (DBE, 2011), teachers did not plan for practical lessons. Another study by Kibirige et al., (2014) showed that the perceptions of teachers on the purpose of practical work was not translated into the practical application. In other words, teachers had positive views regarding the significance of practical work but based on the researchers' observations teachers did not integrate practical work in any of their lessons. Therefore, there seemed to be a mismatch between the teachers views on the significance of practical work and what is enacted during practical work. (Kibirige et al., 2014). Moreover, a study by Chuene and Teane (2024) identified time as an important resource limitation in a science classroom and this affects both the training of teachers as well as the implementation; particularly when it relates to practical work.

2.3.6 Challenges of implementing practical work

Although practical work has been argued to have a lot of benefits in science education, particularly Life Sciences, there has been some studies expressing that it may not be easy to use practical work in lesson. Challenges relating to implementing practical work are as follows: firstly, the beliefs, attitudes and knowledge of teachers. Teachers' use of practical work in their lessons is greatly influenced by their beliefs and knowledge about science teaching and learning methodologies (Boesdorfer & Livermore, 2018). Asori (2023) concurs by noting that the teachers' attitude in carrying out their lesson, which also includes their teaching strategy, also has a great impact on learners' attitudes towards what is being taught. Boesdorfer and Livermore (2018) further make an example by stating that the beliefs a teacher has on the practice of science as well as their understanding of nature of science, has been shown to have an impact on their utilisation of practical work in their teaching (Boesdorfer & Livermore, 2018).

Secondly, a lack of resources poses as a challenge in implementing practical work. Inadequate resources have been mentioned by educators and researchers to negatively affect successful implementation of practical work in the classroom (Boesdorfer & Livermore, 2018). Supporting this issue of lack of resources are findings from a study by Asori (2023), whose study found that laboratory equipment has an important role to play during practical work with biology students. According to Asori (2023), not having enough resources did not assist the learners in achieving what was expected of them. Moreover, Kibirige et al., (2014) point out that in South Africa, poor resources in schools contribute to a noticeable lack of practical work in science classrooms. In the same light, a Rwandan study found that a lack of teacher training and implementation of policies regarding the use of practical work in the high school classroom, together with insufficient facilities and resources negatively affected the use of practical work in teaching and learning science (Niyitanga et al., 2021).

2.4 Theoretical frameworks

2.4.1 Science process skills approach

This research study's conceptual framework was grounded in the science process skills approach developed by Chiappetta and Koballa (2002) in their Science Instruction in the Middle and Secondary Schools book. The approach centers on the teaching of science process skills, which are versatile abilities applicable to many science fields and mirror the behaviour of scientists as described by Padilla (1990) and Chiappetta and Koballa (2002). The definition and descriptions of the science process skills have been outlined in Table 2 below. This framework will be used an analysis lens in Chapter 4.

Table 2 Science process skills adopted from Chiappetta and Koballa, 2002

Basic science process skills: **Observing**: The process of observing involves drawing attention to the characteristics of objects and circumstances through the utilization of the five senses. Sensing information through the body's sense organs. **Measuring:** Assessing the amount of a substance or objective in numerical terms. **Inferring:** Expressing a particular object or substance in numerical terms. **Classifying:** This process involves assigning or categorizing objects and events based on a particular characteristic.

Predicting: Forecasts can be made by relying on research. **Communicating:** Describing and depicting an object, influence, or situation using words, symbols, or tables. **<u>Integrated Science process skills:</u>** **Controlling variables:** Changing variables regulating characteristics associated with state events to establish a basis for analysis. **Hypothesizing:** Proposing a tentative theory based on research or observations that can be used to explain a range of events but is subject to verification by one or more experiments. **Experimentation:** Testing a hypothesis involves experimenting through the deliberate alteration and management of independent variables, the objective is to document the effects on a dependent variable and convey the findings in a manner that enables others to attempt to repeat the experiment. **Data Interpreting:** Obtaining explanations, inferences, or hypotheses can be obtained from the data table or a figure placed in it.

2.4.2 Pedagogical Content Knowledge

According to Chai et al., (2013), Pedagogical Content Knowledge (PCK) is defined as representing content knowledge combined with the use of pedagogical methods to make a particular topic or content easy to understand for learners. Fraser (2016) elaborates by stating that PCK is a teacher's cognitive comprehension of a specific topic as well as the connections between such understanding and method of teaching that the teacher gives their learners. In simpler terms, PCK is said to refer to teachers' knowledge of what strategies and methods of teaching they can use when they teach a subject in the best possible way (Deveci & Acarlı, 2021).

In a study on teacher pedagogical content knowledge by Gess-Newsome et al., 2019) a classroom observation protocol was used to test General Pedagogical Knowledge, which was defined as the capacity to use general teaching techniques in the classroom. According to their study, it was put forward that PCK is both a knowledge foundation and a component of practice (Gess-Newsome et al., 2019).

A variety of knowledge bases, such as content knowledge and (general) pedagogical knowledge, were identified in Shulman's (1986) first attempt to characterise teacher professional knowledge (Neumann et al., 2019). Particularly, Shulman (1986) proposed that PCK is solely educators' responsibility, which the sets them apart from content or "subject" experts. PCK was characterised as a specific combination of content and pedagogy that is distinct to teachers, a unique form of professional expertise, which incorporates how knowledge within a particular subject area is structured and tailored to students' varied needs and aptitudes during instruction. (Neumann et al., 2019).

It has been said that excellent and effective teaching can be described as one whereby both learning and understanding are facilitated, and in order to ensure that the learning of students is enhanced, teachers ought to evaluate their pedagogy (Fraser, 2016). Given this understanding, it can thus be argued that teachers need to be cognizant of their practice and how effective their methods of teaching are (Zeng et al., 2018). It is further pointed out that effective educators are good at developing a strong capacity to intercede the learning of students and further capitalise on a professional knowledge collection that has been constructed on secure knowledge of the content or specific subject matter that is responsive to different learning needs of different individuals (Kind, 2019).

Neumann et al., (2019) state that Shulman (1987) first proposed the concept of teaching as a ‘transformation’ of a subject matter understanding into material, that learners can be able to access. Through this, there was the recognition of numerous additional knowledge bases that a teacher would need in order to accomplish this transformation. These include content knowledge (CK) and (generic) pedagogical knowledge (PK), as well as knowing the curriculum, learners and their characteristics, educational environments, educational ends, purposes, and values, as PCK (Neumann et al., 2019).

However, Sarkar et al., (2024) point out that in the 1980s, Shulman argued that general pedagogy and content knowledge alone are not sufficient for teaching that is effective. Instead, it was argued that the blending of content and pedagogy into an understanding of how certain topics, issues, or problems have been organised, characterised, and adapted to the learners’ different interests and abilities, and presented for instruction, is vital (Shulman, 1987, p. 8). As a theoretical framework, PCK can be used to comprehend how teachers create learning activities and translate their expertise of the subject matter into representations and forms, such as analogies, demonstration and illustrations, that are appropriate for learners’ developmental stages and are meaningful to them (Sarkar et al., 2024). Educators can better explain the "why and how" of their pedagogical approach to teaching certain topic when their method is informed by PCK (Yusof & Effandi, 2015).

It is important to highlight that appropriate practical work, influenced by PCK, enhances learners’ learning (Antwi et al., 2021). Integrating Pedagogical Content Knowledge (PCK) into teaching practices significantly enhances student learning, particularly through the incorporation of appropriate practical activities. PCK enables educators to blend their understanding of subject matter with effective teaching strategies, tailoring instruction to meet students' diverse needs (Mavhunga & van der Merwe, 2020). This integration facilitates the design of learning experiences that connect theoretical concepts to real-world applications, making learning more engaging and meaningful.

According to Hume et al., (2019) emphasised the importance and relevance of PCK in science education. They argued that PCK does not only tie content knowledge and pedagogical skills together, but also supplements teaching practices by integrating hands-on, practical activities (Hume et al., 2019). It is noted that such activities allow learners to actively engage with scientific concepts, which further deepens their understanding and fosters a learning environment that is more interactive (Abrahams & Reiss, 2017). Thus, when the integration of practical work is thoughtfully informed by PCK, a teacher may design learning experiences that are dynamic and enhance comprehension and retention, which further leads to better educational outcomes.

It is commonly understood that PCK is discipline specific and that its roots are in is its ability to facilitate the pedagogical translation of a topic's content knowledge into reconstructed forms that are appropriate for the comprehension of learners (Mavhunga & van der Merwe, 2020). Thus, PCK consists of strategies for designing and delivering information that learners can comprehend, such as using examples, explanations, illustrations, analogies, and demonstrations (Almeida et al., 2019).

It is further noted by Berry et al., (2016), that PCK also includes envisioning the reasons for teaching a certain subject. It is said that PCK deals with how accurately the teacher may recognise the necessity and the goal of working on a given topic in the classroom (Berry et al., 2016). Almeida et al., (2019) contend that this comprehension necessitates first that there is an understanding of how well learner comprehend the material that is being taught, including their experiences, conceptions, thought processes, opportunities, and challenges, as well as other factors that may have an impact on how well learners understand the material that is presented in class. Since it requires coming up with methods to depict and explain the material, this understanding is important for teachers to carry out learning activities (Almeida et al., 2019).

Barendsen and Henze (2019) state that when it comes to PCK, the most referenced model is one by Magnusson, Krajcik & Borko (1999), highlighting three other components to Shulman's definition. Four of these components are parallel to the following fundamentals of pedagogy that are content specific. They look at the objectives and goals for curriculum that is topic-specific, the understanding of learners when it comes to the topic, the teachers' instructional strategies regarding the topic, as well as the methods of assessing learners' comprehension of that topic. These four components are everywhere in that they can be found in a wide range of general educational models found in literature as well as in teacher preparation resources (Barendsen & Henze, 2019).

Moreover, Hwang et al., (2018) found that teachers need Pedagogical Knowledge, which is an understanding of the approaches and methods of teaching which further allow them to repeatedly advance and refine their own ways. It can also be considered as a blend of declarative and practical knowledge (Hwang et al. 2018). Developing the PK of teachers about planning for practical work is argued to have an impact on its effectiveness by making sure that tasks are well-conceived and effective for relating what learning really does in practical work with the concepts teachers aim for them to learn (Darling-Hammond, 2021).

Practical work is said to be a distinctive feature of science teaching and learning and it includes laboratory investigations (Abrahams & Reiss, 2017). Another definition of practical work is any science teaching and learning activity where students, either alone or in small groups, examine and/or work with the materials or objects they are studying (Abrahams & Reiss, 2017). This "hands on" teaching method can assist learners in acquiring science concepts or information, build experimental or practical skills, increase motivation, and comprehend the nature of science and scientific methods (Mansfield, 2023). It can be argued that planning for practical work is a pedagogical act requiring PK. Teacher preparation plays an important role in developing teachers' PK about practical work (Mansfield, 2023).

Hofstein and Lunetta (2004) highlight the factors that may hinder the learning of students through practical work, based on their extensive reviews of science practical work. These factors include: recipe-style tasks where learners are required to think about the purpose of the practical task; limited assessment of learners' practical knowledge, abilities, and awareness of the purpose of practical inquiry, further leading to a perception of practical work as not important; limited resources as well as limited time for educators to develop their PK and implement appropriate practical activities (Mansfield, 2023).

Moreover, another element to highlight that shows the impact of a lack of PK, is how best to plan practical work so that learners have the greatest chance of using the experience to develop their conceptual knowledge (i.e. knowledge of science), skills (i.e. capacity to do science or engage in the practices of scientific inquiry), and understanding of the nature of science (Mansfield, 2023).

2.4.3 Constructivism

The idea that teachers should do more than only teach students is one of the most significant tenets of educational psychology. In their own imaginations, students must create knowledge (Efgivia et al., (2021). A teaching and learning methodology known as constructivism is predicated on the idea that cognition, or learning, is the outcome of "mental construction." Put differently, students acquire knowledge by integrating new information with their existing knowledge (Bada & Olusegun, 2015). Constructivists think that learning is affected by the context in which a concept is presented as well as by students' beliefs and attitudes.

When individuals come across anything new, they ought to make sense of it considering their prior knowledge and experiences. They may need to modify beliefs or dismiss the new information as unimportant. Either way, people actively construct their own knowledge. (Bada & Olusegun, 2015). Several unique teaching techniques that are employed in the classroom may be identified by the constructivist approach to learning. In its most general sense, it usually refers to encouraging students to produce new knowledge through active techniques (experiments, real-world problem solving), after which they should evaluate and talk about their work and the ways in which their understanding is developing. The teacher organises the activity to address and then expand upon the learners' preconceived notions, ensuring that they are understood (Oliver, 2000).

The central idea of constructivism holds that knowledge is created by learners and that prior knowledge serves as the basis for new knowledge. The straightforward concept of created knowledge is the centre of two significant ideas (Allen, 2022). The first is that students use what they already know to create new understandings. New information cannot be written on a blank slate (Antwi et al., 2021). The second idea is that education is not passive but active. Given that practical work is any activity in which the learner observes or works with real or virtual objects and materials, it might be claimed that this relates to science practical education (Antwi et al., 2021). Learners challenge their knowledge based on what they experience in the novel learning environment.

If we accept that constructivist theory is the best way to define learning, then it follows that to promote student learning it is necessary to create learning environments that directly expose the learner to the material being studied (Zajda & Zajda, 2021). For only by experiencing the world directly can the learner derive meaning from them. One of the central tenants of all constructivist learning is that it must be an active process; therefore, any constructivist learning environment must provide the opportunity for active learning (Zajda & Zajda, 2021). With the constructivist model, students are encouraged to actively participate in their own learning process, and the teacher serves more as a coach, mediates, prompts, and assists students in developing and evaluating their understanding, and consequently their learning. The emphasis tends to shift from the teacher to the students, the classroom no longer being a place where the teacher ("expert") pours knowledge into passive students who wait like empty vessels to be filled.

In a systematic review by Oliveira and Bonito (2023), it was found that practical work contributes to the important mission of mitigating arguments, beliefs, and/or alternative conceptions, without scientific background, contributing to the formation of better-informed individuals, and able to apply critical thinking. Therefore, this relates to the constructivist theory in that when learners encounter something new, they must reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. Moreover, it is added that through practical work, learners engage in skills that include critical thinking, problem-solving, and inquiry-based learning, which are important outcomes of STEM education (Tsakeni, 2022).

In addition, Oliveira and Bonito (2023) also highlighted that practical work involves students in scientific themes, developing their relevant knowledge on these topics, hands on skills and conceptual understanding (minds on), involving students simultaneously in the process of building their own knowledge, shows the importance of a constructivist perspective.

The diagram in Figure 1 below illustrates constructivism as the main learning theory in which learners construct their own knowledge; PCK represents the teachers' ability to successfully integrate teaching strategies, while also fostering the development of science process skills in learners, enabling them to participate in scientific inquiry. The three theoretical frameworks are closely interconnected. Constructivism and PCK involve teaching methods that enable learners to construct knowledge through active engagement. Both constructivism and science process skills involve inquiry-driven learning where learners employ scientific skills while investigating concepts. Thirdly, PCK and science process skills has to do with how teachers effectively guide learners in developing these skills. In essence, the three frameworks are interconnected to establish a successful science education environment, where learners engage in active learning, supported by well-structured teaching methods that enables them to develop their science process skills.

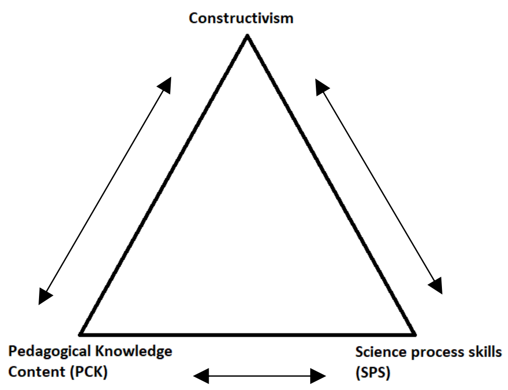


Figure 1 The proposed relationship between the three theoretical frameworks

Therefore, constructivism, PCK and science process skills relate to this study considering that they look at practical work in science education from different perspectives, as they provide important insights on how practical work can enhance learning and teaching as well as how science process skills can be developed during practical work.

2.5 Conclusion

This chapter discussed the literature review. It began by reviewing studies relating to science process skills and practical work. A review of existing research revealed that both globally and within South Africa, there is a recognition of the significance of science process skills and practical work. The chapter also reviewed theoretical frameworks underpinning this study. The next chapter discusses the methodology employed in this study.

Chapter 3

Methodology

3.1 Introduction

The purpose of the study was to investigate whether food tests practical work provided the opportunities for teachers to develop science process skills in learners. In addition, the study intended to identify which science process skills can be developed through doing practical work on food tests. The research methodology used in this study aimed at extracting useful information from the teacher who facilitated the practical work to the learners. The chapter outlines the research paradigm, research objectives, research design, research setting, the participants of the study, data sources and data analysis techniques, issues of validity and reliability of data sources that were used to gather data as well as ethical considerations.

The main purpose was addressed by seeking answers to the following specific research question:

How does practical work in food tests provide opportunities to develop science process skills in Life Sciences?

To address the main research question the following research sub-questions were answered:

- Which science process skills can be developed through food tests practical work?
- How were the food tests practical work carried out in this study?
- Which science process skills, if any, were assessed in the practical assessment task?

This chapter aimed mainly to discuss research design of the study, study sample, data sources and data analysis techniques that were used to get findings for the research.

3.2 Research paradigm

This study adopts an interpretivist research paradigm to investigate how food tests practical work offers opportunities for learners to develop science process skills. This paradigm prioritizes the comprehension of meaning-construction processes in particular settings. Furthermore, it seeks to gain in-depth insights into the opportunities and constraints of food tests practical work in developing science process skills, ultimately contributing to a deeper understanding of science learning in the classroom.

3.3 Research objectives

The objectives of this study were driven by the aim of investigating the opportunities to develop science process skills in the food tests practical work in Grade 10 Life Sciences. Specifically, the study sought to:

i. analyse the Curriculum Assessment Policy Statement (CAPS, DBE 2011) Life Sciences' sections to determine which science process skills should be implemented in Life Sciences.
ii. examine the role of the practical handout used in the lesson to determine how it supports or constrains learners' engagement with science process skills.
iii. identify the opportunities created by the teacher to foster the development of science process skills during food tests practical work.
iv. draw insights from the teacher's interview to provide a holistic understanding of how food tests practical work contribute to the development of science process skills in Grade 10 learners.
v. analyze the practical assessment task to establish the extent to which it assesses science process skills.

3.4 Research design

The researcher implemented a deliberate, organized and structured approach to gather and analyse data. Myers (2019) describes research methodology as an inquiry process that connects fundamental concepts with the research design and data collection process. Creswell (1999) views qualitative research as a methodologically grounded process, where researchers develop a comprehensive framework by analysing accounts and observations, and conduct the research within its environment. This research employed qualitative methodology incorporating practical work lesson observation, and an interview with the teacher who facilitated the lesson. This approach was selected because, within it, the researcher was best positioned as an objective observer who neither engaged nor affected the subject being studied. The study involved multiple data sources, namely the CAPS document (Appendix A) and the practical handout (Appendix B), video recording of the practical lesson (Appendix C), the teacher interview (Appendix D) and the practical assessment task (Appendix E).

3.5 Research setting

The study was conducted at a public high school situated in Johannesburg East District. The school is modern and well-equipped, with facilities such as specialized classrooms, science laboratories, a library, sports fields and spaces for cultural activities. This school prides itself for providing a conducive environment for learning and development. The study focused on learners in Grade 10 doing Life Sciences, this is their first year in the Further Education Training (FET). In the South African curriculum learners in Grade 9 choose specialist subjects to complete in the FET phase. The broad topic studied was *The Chemistry of Life*, specifically *Organic Compounds as* described in Chapter 1, section 1.2 in the background of the study.

3.6 Participants of the study

According to Borg and Gall (1989) sampling means selecting a given number of subjects from a defined population as representative of that population. One school was chosen for a more in-depth examination, which will yield detailed insights that could be missed in broader studies. The school was chosen for the study due to a variety of reasons using a method of purposive sampling. Firstly, the study was carried out in a well-resourced school to ensure that the investigation of opportunities to develop science process skills is not limited by lack of facilities or materials. Food tests practical work require access to laboratory equipment, including reagents and learning materials which provided a conducive environment for the purpose of the study. Secondly, the school was conveniently located near the researcher, allowing for frequent visits that facilitated continuous observation and timely data collection, ultimately enhancing the consistency of the results.

Participants for this study were chosen based on the following criteria:

- One high school near the researcher was selected. A school must have at least one Grade 10 Life Sciences class.
- One teacher was sampled based on that he or she teaches Life Sciences in Grade 10. The teacher had to be teaching Life Sciences at the sampled school.

In this study, one participant was purposefully selected to offer in-depth insights into the opportunities for developing science process skills through food tests practical work The rationale for using a single participant was influenced by the study's exploratory nature and the need to obtain rich, detailed data that might be diluted in a larger sample. The study was able to investigate the opportunities offered for the development of science process skills during food tests practical work. The study was able to identify and record detailed lesson observations and the participant teacher’s insights that may have been overlooked in a larger sample. However, the use of a single participant is also acknowledged as a limitation of the study, as it restricts the generalisability of the findings to wider contexts.

3.7 Data sources

The tools used to collect data for a study are commonly referred to as data collection instruments (Opie, 2019). One instrument was used, the teacher interview, the rest of the items below are data sources which will attempt to answer the main research question.

1. CAPS document analysis (DBE, 2011)
2. Practical handout
3. Video recording of the practical lesson
4. Teacher interview

5. Practical assessment task

These data sources were specifically selected for this study due to their distinctive features, including their capacity to yield a substantial data set, which aligned with both the methodology and the research approach adopted in this investigation, thereby demonstrating their appropriateness for this study.

3.7.1 CAPS document (DBE, 2011)

The Curriculum Assessment Policy Statement (CAPS, DBE 2011) is the official prescribed educational framework in South Africa. The current study focuses on the Life Sciences, Grade 10 – 12 CAPS document. The document emphasizes the development of science process skills as an essential component of learning science. According to CAPS (DBE, 2011), these skills enable learners to engage in scientific inquiry, problem-solving, and critical thinking. The CAPS document holds significance in the current study, as the researcher aimed to determine the extent to which science process skills were referenced within the document. Moreover, CAPS provides a wealth of data that corresponds with the current study's research objectives as it serves as an essential reference point (see Appendix A).

3.7.2 Practical handout

Learners were given a practical handout (see Appendix B) which was a document provided to guide them through food tests practical work. The teacher designed this handout using a variety of sources. The practical handout served as an instructional guide and reference for recording observations. The practical handout had the following components:

- Title and introduction which clearly states the name of the experiment.
- The aim of the investigation detailing what learners are expected to achieve
- The apparatus and chemical required to perform the experiment.
- The method which gives a step-by-step guide on how to carry out the experiment. Some experiments included diagrams to show the learners how to set up the equipment.
- The safety precautions are highlighted to ensure that learners are working in a safe environment
- The conclusion summarizing the experiment

3.7.3 Video recording of the practical lesson

Marshall and Rossman (2014) describe observation as "the systematic description of events, behaviours, and artefact in the social setting chosen for the study" (p. 79). Watching the video recording of observations is beneficial as it can be viewed multiple times and allows for transcription, resulting in rich data that can be used to verify the accuracy of interpretations and eliminate potential biases (Opie, 2004). This qualitative method involves observing participants to gather insight into the viewpoints held by the population being researched. The researcher can accomplish this by observing alone or by combining observation with participation, to different extents. In this study, the researcher was not a participant, therefore she just observed lesson proceedings alone in silence.

The observations in this study were utilized for three purposes:

(i) To investigate whether there were opportunities for the development of science process skills
(ii) To see which science process skills were developed
(iii) To investigate the teacher's role in the development of science process skills

The video recording of the practical lesson aimed to firstly identify science process skills that could be developed in learners and secondly to gather evidence of the teacher's role in creating opportunities for the development of science process skills in learners. The practical work consisted of teacher-led demonstrations, lectures, and very little exchanges between the teacher and the learners. Once the food tests practical work was completed, the researcher reviewed the video recording, played it several times and transcribed the interactions (see Appendix C).

3.7.4 Teacher interview

At the end of practical work, the Life Sciences teacher was interviewed (see Appendix D). When constructing an interview schedule, researchers should incorporate questions that are likely to provide significant information about the study phenomenon and align with the research aims and objectives, as suggested by Gill et al. (2008). The researcher can pursue additional ideas, delve deeper into responses, and examine motivations that other tools are incapable of measuring. Non-verbal cues conveyed through a response can offer insight that a written statement would obscure, and when executed by an interviewer, it can be highly beneficial, as noted by Gall & Borg (1989). The study comprised of a semi-structured interview which was used in conjunction with the data collected through the video recording of the practical lesson to enhance the credibility and reliability of the study's findings (Patton, 2002). The teacher interview was intended to establish two aspects. Firstly, whether the teacher, in her perspective provided opportunities for learners to develop science process skills during the practical work. Secondly, her pedagogical reasonings on how she conducted the food tests practical work. This is due to the fact that semi-structured focus interviews enable the researcher to gauge participants' initial comprehension at the outset of the study while still allowing for varied perspectives that may uncover additional insights connected to their initial viewpoints (McIntosh & Morse, 2015).

3.7.5 Practical assessment task

The learners were required to complete a practical assessment task (see Appendix E) as a closed-book test to assess their practical knowledge and skills acquired during the term. The practical assessment task was school-based assessment (SBA) which was created and moderated by the Life Sciences teachers from the selected school. According to CAPS (DBE, 2011) practical assessment tasks should range between 20 to 40 marks. They must cover the range of skills described in Specific Aim 2 (see Appendix A).

3.8 Data analysis

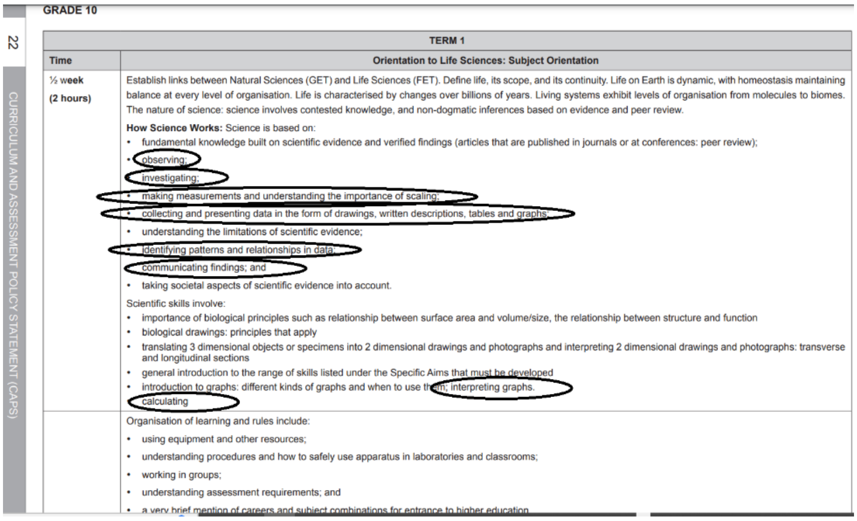
3.8.1 Analysis of Curriculum Assessment Policy Statement (CAPS) document

The aim of analysing the CAPS document was to identify the science process skills that Life Science teachers are expected to develop in learners generally but more specifically through food tests practical work. To achieve this aim, the researcher read through pages 15 to 17 of the CAPS document highlighting the science process skills that are mentioned in the document. Chiappetta and Koballa (2002), proposed ten science process skills which were used as the lens for identifying the process skills. The lens was discussed in chapter 2. The researcher summarised it in Table 2 below for convenience.

Table 2 Science process skills proposed by Chiappetta and Koballa (2002)

Basic science process skills:
Observing: The process of observing involves drawing attention to the characteristics of objects and circumstances through the utilization of the five senses. Sensing information through the body's sense organs.
Measuring: Assessing the amount of a substance or objective in numerical terms.
Inferring: Expressing a particular object or substance in numerical terms.
Classifying: This process involves assigning or categorizing objects and events based on a particular characteristic.
Predicting: Forecasts can be made by relying on research.
Communicating: Describing and depicting an object, influence, or situation using words, symbols, or tables.
Integrated Science process skills:
Controlling variables: Changing variables regulating characteristics associated with state events to establish a basis for analysis.

Hypothesizing: Proposing a tentative theory based on research or observations that can be used to explain a range of events but is subject to verification by one or more experiments.
Experimentation: Testing a hypothesis involves experimenting through the deliberate alteration and management of independent variables, the objective is to document the effects on a dependent variable and convey the findings in a manner that enables others to attempt to repeat the experiment.
Data Interpreting: Obtaining explanations, inferences, or hypotheses can be obtained from the data table or a figure placed in it.


22 CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS)

GRADE 10

TERM 1	
Time	**Orientation to Life Sciences: Subject Orientation**
½ week **(2 hours)**	Establish links between Natural Sciences (GET) and Life Sciences (FET). Define life, its scope, and its continuity. Life on Earth is dynamic, with homeostasis maintaining balance at every level of organisation. Life is characterised by changes over billions of years. Living systems exhibit levels of organisation from molecules to biomes. The nature of science: science involves contested knowledge, and non-dogmatic inferences based on evidence and peer review. **How Science Works:** Science is based on: • fundamental knowledge built on scientific evidence and verified findings (articles that are published in journals or at conferences: peer review); • observing; • investigating; • making measurements and understanding the importance of scaling; • collecting and presenting data in the form of drawings, written descriptions, tables and graphs; • understanding the limitations of scientific evidence; • identifying patterns and relationships in data; • communicating findings; and • taking societal aspects of scientific evidence into account. Scientific skills involve: • importance of biological principles such as relationship between surface area and volume/size, the relationship between structure and function • biological drawings: principles that apply • translating 3 dimensional objects or specimens into 2 dimensional drawings and photographs and interpreting 2 dimensional drawings and photographs: transverse and longitudinal sections • general introduction to the range of skills listed under the Specific Aims that must be developed • introduction to graphs: different kinds of graphs and when to use them; interpreting graphs. • calculating
	Organisation of learning and rules include: • using equipment and other resources; • understanding procedures and how to safely use apparatus in laboratories and classrooms; • working in groups; • understanding assessment requirements; and • a very brief mention of careers and subject combinations for entrance to higher education

Figure 2 Science process skills on the CAPS document

Figure 2 above shows how the science process skills were coded on a copy of the CAPS document (DBE, 2011). The researcher first coded a small section (p. 22) of the CAPS FET grades 10-12 Life Sciences booklet. The researcher then requested a friend to independently code the same section of the document as a way of validating the coding. They read through the section and coded. After that the researcher and a friend sat down and compared the coding and discussed the differences. Then the inter-rater reliability was calculated by dividing the number of times the coding was similar with the total number of ratings that was agreed on and it was 75%. The process was repeated two more times with two other sections until the inter-rater reliability was 90%. Thereafter, pages 15 to 17 were coded because this is where the CAPS document states the sciences process skills needed to be developed in Life Sciences.

3.8.2 Analysis of the practical handout

The aim of analysing the handout was to see how it was structured and secondly to identify the science process skills that can be developed using this document. The handout was analysed according to the sub-headings of a basic investigation namely, aim, apparatus, method, discussion, conclusion and precautions stated. It was arranged according to the four food tests investigations, (i) food test for starch which is coded as *S, (ii)* food test for glucose coded as *G,* (iii) food test for lipids coded for *L* and (iv) food test for proteins for *coded as P.* For the second part of the analysis, the researcher thoroughly reviewed the document using the lens to identify the science process skills it references.

3.8.3 Analysis of practical work teaching video

Marshall and Rossman (2014) describe observation as “the systematic description of events, behaviours, and artefact in the social setting chosen for the study” (p. 79). This qualitative method involves observing participants to gather insight into the viewpoints held by the population being researched. The researcher can accomplish this by observing alone or by combining observation with participation, to different extents.

The aim of analysing the recorded practical lesson (see Appendix D) was to identify opportunities of developing science process skills through food tests practical work, secondly, to see which science process skills, if any, were developed during the practical work, and lastly to investigate the teacher’s role in the development of science process skills. To achieve this aim, the researcher, after recording the practical lesson, identified and selected video footage that supported the study’s research objective by using the lens to identify the science process skills and also capturing the interactions of the participants in the video recording. Then the researcher transcribed the video content. Thereafter a coding system was established to categorize distinct themes that appear in the video. This coding framework was deductively based on existing lens used. Themes were extracted from the coded data. To increase the accuracy of the analysis, the researcher validated the findings by seeking input from a friend to confirm the reliability of the conclusions.

3.8.4 Analysis of teacher interview

The researcher next sought to uncover the teacher's pedagogical reasoning, and as a result, conducted an interview with the teacher. The interview was audio-recorded. The researcher listened to the audio-recording several times to become familiar with the teacher's comments. The researcher proceeded to transcribe the respondents' answers. Thereafter the researcher subsequently requested a colleague to review the transcript for validation purposes.

3.8.5 Analysis of practical assessment task

Almost a month after the food tests investigations were demonstrated by the teacher, 17 learners were given the practical assessment task as a formal assessment. Generally, assessments are conducted towards the end of the term to enable learners to utilize the knowledge and skills they have acquired during the term. After the practical assessment task was marked by the teacher, the assessments were scanned and emailed to the researcher. Thereafter, the researcher then analysed the responses to establish whether learners' science process skills were developed during the food tests practical work. Excel was used to record, calculate and analyse the learners total scores, averages and overall performance.

3.9 Reliability and validity

3.9.1 Reliability

The extent to which an instrument produces consistent and stable outcomes is referred to as its reliability. According to Joppe (2000), reliability in research is characterised by the consistency of results over time and the accurate representation of the population being studied. Furthermore, if the findings of a study can be replicated using a similar methodology, then the research tool is deemed reliable (p. 1). Rule and John (2011) believe that conducting research in a proper manner is expected to enhance the quality of the research and increase its credibility. To ensure reliability the triangulation of data sources which included the following documents: the CAPS document (DBE, 2011), the practical handout and the practical assessment task, including collecting information from the classroom observation and the teacher's interview thereby enhancing the consistency of the findings.

3.9.2 Validity

The issue of validity raises the question of whether the instruments being used are accurately measuring the intended variables. One way of ensuring validity is the use of multiple instruments (Kimberlin and Winterstein, 2008). In addition to the practical lesson, this study produced qualitative data through interviews and a practical assessment task. Triangulation typically involves verifying data by utilizing alternative data sources or collection methods (Creswell & Miller, 2000). Triangulation in this study was achieved by drawing on multiple data sources to strengthen the validity and reliability (Flick, 2018). The CAPS document (DBE, 2011) and the practical handout were analysed to determine which science process skills can be developed, collaboratively answering the sub-question "Which science process skills can be developed through food tests practical work?". The video recording of the practical lesson was used to capture the opportunities created by the teacher to develop science process skills. While the teacher's interview offered further depth insight into their perceptions and rationale regarding the development of science process skills during food tests practical work. Together these data sources answered the sub-question "How were the food tests practical work carried out in this study?". Lastly, the practical assessment task will be analysed to determine which science process skills were assessed answering the last sub-question "Which science process skills (if any) were assessed in the practical assessment task?". All the data sources show the extent in which the development of science process skills are supported or constrained.

3.10 Research Ethics

Ethical considerations refer to the moral principles or rules of behaviour that you as a researcher must consider before and throughout your study (Chiumento et al., 2017). Pseudonyms have been assigned to participants to maintain their confidentiality, and these are used consistently throughout this study (Taber, 2013). This study will use a pseudonym, Mercy* to refer to the Life Sciences teacher.

Moral and ethical principles guide a researcher's actions, influencing their decisions and conduct from the outset to the completion of a study (Chiumento et al., 2017). In accordance with the study's code of ethics, the rights of the participating respondents were safeguarded. The university's ethics committee was asked for approval to conduct the research. A further request for permission to conduct the research was submitted to the Director of Education Research and Knowledge Management of the Gauteng Department of Education (GDE).

Speziale et al., (2011) have identified two key sets of ethical considerations when using a qualitative approach. All participants in this research provided voluntary consent, free from coercion or undue influence, and were able to opt out at any point during the study. The following four principles of ethical concerns must be considered prior to conducting research: These are as outlined in Beauchamp and Childress's work, initially published in 1983 and further referenced in Lund and Forsberg (2009).

The initial ethical principle is autonomy, which, as Polit and Hungler (1999) note, involves respecting individuals' rights to self-determination and their entitlement to complete disclosure. The participants were informed about the study's nature and what it would entail for them, that they would not encounter any unforeseen situations.

The second principle is the beneficence, which guarantees that the research will demonstrate benevolence, magnanimity, and fairness towards the participants.

The third ethical principle, non-maleficence, was also ensured for participants. This principle provides reassurance to parents that their children are consistently in a secure environment and will not be put at risk by the research.

The final ethical principle examined was justice, specifically in terms of fairness and equity. The report ensured participants' anonymity by putting confidentiality procedures in place.

3.11 Conclusion

This study was designed with the aim of investigating opportunities for the development of science process skills in learners. In this chapter, the research methodology and design were outlined. This chapter described the sample, data collection procedures, methods of data analysis. It also explained issues of reliability and validity including research ethical considerations.

Chapter 4

Presentation and discussion of findings

4.1 Introduction

The methodology employed in the study was presented in chapter 3. This chapter presents and discusses the findings of the study. Information to answer the main research question will be presented in this chapter, which is:

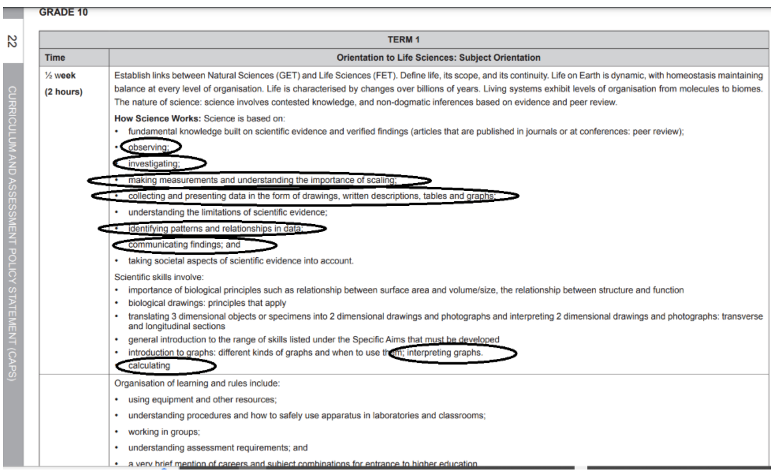
How does practical work in food tests provide the opportunities to develop science process skills in learners?

The presentation and discussion will be done under the following sub-headings which have been derived from the research sub-questions:

1. **Which science process skills can be developed through food tests practical work?**
2. **How were the food tests practical work carried out in this study?**
3. **Which science process skills, if any, were assessed in the practical assessment task?**

4.2 Which science process skills can be developed through food tests practical work?

The Curriculum Assessment Policy Statement (CAPS, DBE, 2011) document stresses the importance of developing science process skills as a fundamental aspect of learning science. According to CAPS (DBE, 2011) these skills allow learners to participate in scientific investigation, problem-solving, and critical thinking. The CAPS document is of importance in this study, as the researcher sought to establish the extent to which science process skills were mentioned within the document.


GRADE 10

22

CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS)

TERM 1	
Time	Orientation to Life Sciences: Subject Orientation
½ week (2 hours)	Establish links between Natural Sciences (GET) and Life Sciences (FET). Define life, its scope, and its continuity. Life on Earth is dynamic, with homeostasis maintaining balance at every level of organisation. Life is characterised by changes over billions of years. Living systems exhibit levels of organisation from molecules to biomes. The nature of science: science involves contested knowledge, and non-dogmatic inferences based on evidence and peer review. **How Science Works:** Science is based on: • fundamental knowledge built on scientific evidence and verified findings (articles that are published in journals or at conferences: peer review); • observing; • investigating; • making measurements and understanding the importance of scaling; • collecting and presenting data in the form of drawings, written descriptions, tables and graphs; • understanding the limitations of scientific evidence; • identifying patterns and relationships in data; • communicating findings; and • taking societal aspects of scientific evidence into account. Scientific skills involve: • importance of biological principles such as relationship between surface area and volume/size, the relationship between structure and function • biological drawings: principles that apply • translating 3 dimensional objects or specimens into 2 dimensional drawings and photographs and interpreting 2 dimensional drawings and photographs: transverse and longitudinal sections • general introduction to the range of skills listed under the Specific Aims that must be developed • introduction to graphs: different kinds of graphs and when to use them; interpreting graphs. calculating
	Organisation of learning and rules include: • using equipment and other resources; • understanding procedures and how to safely use apparatus in laboratories and classrooms; • working in groups; • understanding assessment requirements; and • a very brief mention of careers and subject combinations for entrance to higher education

Figure 3 Science process skills on the CAPS document

The results show that a wide range of science process skills in Figure 2 above are expected to be developed in learners in Life Sciences. As can be seen in Table 3 below, CAPS (DBE, 2011) shows that Grade 10 learners are expected to have the ability to observe, measure, communicate, control variables, hypothesise, experiment and interpret data.

Table 3 Science process skills in CAPS Grade 10 Term 1

Science process skills			
Basic		**Integrated**	
Observing	✓	Controlling variables	✓
Measuring	✓	Hypothesising	✓
Inferring	-	Experimentation	✓
Classifying	-	Data interpreting	✓
Predicting	-		
Communicating	✓		

While there are many science process skills that learners are expected to develop through learning Life Sciences, the CAPS document (DBE, 2011) proposes seven generic science process skills that learners should develop through carrying out an investigation. These skills are presented and explained in Table 4 below.

Table 4 CAPS generic skills

Generic skill	Explanation	Specific skills
1. Following instructions	This is an important skill particularly in lower grade levels and in big classrooms. Teachers should not expect learners using unfamiliar equipment on their own without first providing them with a well-defined set of guidelines to adhere to.	• Adhering to safety rules • Following precautions
2. Handling apparatus	It is essential to be familiar with the laboratory equipment which involves being able to identify and describe its purpose. The learner should be proficient in utilizing a variety of equipment.	• Using laboratory equipment correctly • Memorising the names of the apparatus

3. Observing	A range of observations can be made and recorded in various formats	• Drawing • Descriptions • Classifying materials based on observable similarities or differences.
4. Recording data	Recording information should be done through various methods such as drawings, written descriptions, simple tables, and basic graphical representations.	• Record observations • Recording data in a graphical form
5. Measuring	Learners should be aware of what to measure, how to measure, and possess an understanding of the necessary level of precision.	• Measure using different physical properties such as length, volume, temperature, weight, mass etc.
6. Interpreting	Learners need to be able to convert information from one format in which it was documented into another.	• Drawing a graph using a table of data. • Extract and analyse data from tables, graphs, charts and link to theorical concepts • Identify recurring patterns and trends
7. Designing investigations	Learners should know how to follow the scientific method in an attempt to find answers to scientific questions. It is also essential for learners to plan and design an investigation.	• Identifying a problem • Hypothesising • Selecting suitable laboratory equipment • Identifying dependent, independent and controlled variables • Planning an investigation • Design an investigation

Although CAPS (DBE, 2011) stipulates the importance of developing science process skills in Life Sciences, these seven skills and the associated specific skills are not expected to be fully developed simultaneously but rather teachers are expected to choose relevant skills that can be assessed within the context of particular activities or topics. However, by the end of the

Grade 10 year, learners should have been exposed to all seven science process skills and must have been assessed at a level suitable for that grade. Considering this information, the researcher revisited the *Organic Compounds* section in the CAPS document to ascertain which of the seven science process skills and the specific skills linked to them may be developed by teachers through food tests practical work.

TERM 1		
Organic Compounds • carbohydrates - monosaccharaides (single sugars), e.g., glucose and fructose; disaccharides, (double sugars), e.g., sucrose and maltose; polysaccharides (many sugars), e.g., starch, cellulose and glycogen; • lipids (fats and oils) - 1 glycerol and 3 fatty acids: unsaturated and saturated fats; cholesterol in foods; and heart disease *(link to Grade 9);* • proteins - amino acids (C,H, O and N and some have P, S, Fe) - are sensitive to temperature and pH: loss of structure and function; the role of enzymes in breaking down/synthesising molecules; the influence of temperature and pH on enzyme action; the Lock and Key Model of how enzymes work; enzymes in everyday life (for instance using washing powders); • Mention of nucleic acids - DNA and RNA - consisting of C, H, O, N and P (no details of structure required); and • vitamins - e.g., A, one of the B vitamins, C, D and E. *(Simple diagrams to represent molecules. Review briefly why these substances are needed in plants and animals i.e. build on prior knowledge. Do not give detail of structure or function - functions will be dealt with in later sections where appropriate. This is a brief introduction to the molecular make-up of organisms.)*	**Essential:** • Food tests for starch, glucose, lipids and proteins. • Investigate the working of a 'biological' washing powder (containing enzymes). OR • Hydrogen Peroxide and chicken liver to demonstrate the effect of enzymes. OR • Fresh pineapple juice and solid egg white in a plastic drinking straw. AND • Observe, measure and record results of the experiment done at different temperatures. • Compare the Recommended Daily Allowance (RDA) with usual diet of individual learners. Draw a pie chart of the food types and discuss implications of the usual diet of learners.	• Chemicals • Bunsen burners • Thermometers • Washing powder • H_2O_2 and chicken liver or • Pineapple juice, egg white and plastic drinking straws

Figure 4 Science process skills in Organic Compounds (CAPS, DBE 2011)

Using the information in Figure 3 above, the researcher determined both the generic and specific skills. These were discussed with and face validated by the researcher's supervisor and a Life Sciences expert. Table 5 below shows the science process skills and the specific skills that can be developed in learners in the section of 'Organic Compounds'.

Table 5 Shows science process skills in the 'Organic Compounds' section

Science process skills	Findings from 'Organic Compounds' section
Observing:	• Observe, measure and record results of the experiment done at different temperatures
Measuring:	• Observe, measure and record results of the experiment done at different temperatures
Inferring:	-
Classifying:	• Compare the Recommended Daily Allowance (RDA) and drawing pie chart of food types.
Predicting:	-
Communicating:	• Observe, measure and record results of the experiment done at different temperatures • …discuss implications of the usual diet of learners
Controlling variables: Hypothesizing: Experimentation:	• Food tests for starch, glucose, lipids and proteins • Investigating the way in which biological washing powder (containing enzymes) work

	• Hydrogen peroxide and chicken liver to demonstrate the effect of enzymes • Fresh pineapple juice and solid egg white in a plastic drinking straw
Data interpreting:	• Draw a pie chart of food types and discuss implications of the usual diet of learners

It is important to note that according to the CAPS document (DBE, 2011), under the topic Organic Compounds the following are essential investigations that should be carried out:

(i) food tests for starch, glucose, lipids and proteins

(ii) investigating the way in which biological washing powder (containing enzymes) work

On the other hand, the following investigations are optional and may be included while presenting the topic of 'Organic Compounds':

(iii) Hydrogen peroxide and chicken liver to demonstrate the effect of enzymes

(iv) Fresh pineapple juice and solid egg white in a plastic drinking straw

(v) Observe, measure and record results of the experiment done at different temperatures

(vi) Compare the Recommended Daily Allowance (RDA) and drawing pie chart of food types.

The findings of the study revealed that Grade 10 learners are expected to have the ability to observe, measure, communicate, control variables, hypothesise, experiment and interpret data. It is important that the Life Sciences syllabus incorporates these skills throughout the course of the year. This finding resonates with Yumusak's (2016) research, which studied science curricula in Turkey and identified that science process skills are included in the Turkish science curricula.

In this section the researcher presents the results of the practical handout (see Appendix B) which was given to the learners for the food tests investigations. The practical handout had instructions for the food tests in the following order: test for starch *(S),* test for glucose *(G),* test for lipids *(L)* and test for proteins *(P).* The structure of the practical handout is summarised in Table 6 below.

Table 6 Handout for food tests

Food tests	Aim	Apparatus	Method	Discussion	Conclusion	Precautions
S	✓	✓	✓	x	x	✓
G	✓	✓	✓	x	✓	✓
L	✓	✓	✓	x	✓	x
P	✓	✓	✓	✓	✓	x

As can be seen in Table 6 above, the practical handout contained detailed instructions of how to carry out the investigations including stated aims, apparatus, method and conclusion. All food test investigations included the aim, apparatus, method and conclusion. However, the food test for starch did not have a conclusion. It is noteworthy that only the food test for proteins consisted of a brief discussion, yet the rest of the food tests did not. Precautions were outlined for food test for starch and glucose only. The document has provided the learners with all the information, encompassing stated aims down to conclusions, this suggests that the investigations did not occur, given that expected outcomes were already mentioned.

Having seen that the practical handout appears to include the information, the researcher turned their attention to opportunities for developing science process skills that the document was showing. Table 7 below presents results of the practical handout with reference to the science process skills that can be potentially developed.

Table 7 Science process skills in handout

Science process skills	Evidence from practical handout
Observing:	"Observe the colour of each type of food…" (S) "Observe and record the colour in the table below" (G) "Note the colour change in the test tubes" (P)
Measuring:	"Dissolve this mixture in 20ml of water" (S) "Half fill the beaker with water…" (G) "Add 5ml of ethanol (ether) to each of the two small test tubes" (L) "…mixing a 10ml sodium hydroxide with a few drops of 1% copper sulphate solution" (P)
Inferring:	-
Classifying:	"…compare it to the colour change of starch after adding iodine" (S) "On heating the change of colour from blue to green to yellow and orange/brick red…" (G) "…blue liquid that changes to purple when proteins are present and to pink in the presence of short chains of polypeptides." (P)
Predicting:	-
Communicating:	"Label test tubes as A and B" (G) "Mark the position of the drop." (L)
Controlling variables:	"For the control put half a spatula-full of starch powder…" (S) "Put a drop of pure ethanol on another piece of filter paper. This is your control" (L) "Quarter fill test tube T_1 with the egg white solution and test tube T_2 with starch solution" (P)
Hypothesizing:	-
Experimentation:	"Leave experiment for 30 seconds without disturbing the test tubes" (S) "Wait for 5 minutes then observe and record the colour of the solutions" (G) "Put a drop of the oil in ethanol solution…" (L)
Data interpreting:	-

Note: Food test for Starch (S), food test for Glucose (G), food test for Lipids (L), food test for Proteins (P)

The practical handout showed several opportunities for developing science process skills in learners as shown in Table 7 above, there is evidence that learners could observe, measure, classify, communicate, control variables and experiment. The findings of the study revealed that the handout provided detailed instructions for conducting each food test investigation outlining the aims, methods, expected results, discussions and the conclusions. As a result, it constrained the opportunities for learners to develop their science process skills. It appears that the investigations did not take place because the results were previously referenced and written on the prepared boxes of the food test investigations. This finding was in line with Aydin-Gunbatar et al., (2019) findings in Turkey on teacher's science process skills development and their use of science process skills in activity plans, revealed that at the beginning of their study, teachers designed activities that included all the details such as the aim of the activity and how to gather data etc. The authors argue that although experienced chemistry teachers can design practical work that encompasses science process skills (such as formulating hypotheses, experimenting etc.), in practice there is still a considerable gap in their actual use (Aydin-Gunbatar et al., 2019).

If this handout was used properly, six of the ten science process skills could have been developed. The practical handout's format turned out to be overly prescriptive, as it gave learners pre-set results instead of enabling them to derive conclusions through their own scientific investigation. The learners were mainly asked to observe their teacher carrying out the demonstrations, then confirm and highlight the stated result from each food test investigation. Consequently, opportunities for developing science process skills were limited. The handout could have included blank spaces where learners write their own predictions, formulate hypotheses, record any observations using tables and graphs, analyse data, and draw their own conclusions.

Even though there are several science process skills that learners are expected to develop through learning Life Sciences as stated in CAPS (DBE, 2011), in this study this was not evident in the classroom. This finding is in line with Bekalo and Welford (2000) who found that despite policy statements encouraging active approaches to learning, the actual practice of science teaching differed significantly from the intended curricula in terms of the development of science process skills. The authors found a comparison of the intended and implemented curriculum revealed a significant lack of coherence.

4.3 How were the food tests practical work carried out in this study?

The theoretical aspect underpinning the food tests practical work had been taught several weeks before the investigations were conducted. Learners were expected to recall and apply their prior knowledge. To gain a comprehensive understanding of how food tests practical work is carried out, the researcher observed, and video recorded the lesson. In the section that follows, the findings will be presented. The school's laboratory assistant helped in getting all the apparatus and specimen needed for each investigation. Figure 4 below shows the set-up for each food test investigation.

S G L P

Figure 4 Food test investigations set up

It is important to note that all four boxes were labelled as follows:

- The first box (S) – Test for starch
- The second box (G) – Test for glucose
- The third box (L) – Test for lipids
- The fourth box (P) – Test for proteins

The box *S* contained the iodine solution, iodine crystals, one beaker, a watch glass, an evaporating dish, a plastic teaspoon and pieces of white bread. Box *G* contained the reagent Benedict's solution, one beaker, glucose solution, sucrose solution, Fehling's solution A and B. Box *L* contained filter paper, ethanol, cooking oil, two beakers, an evaporating dish, a watch glass and peanuts. Box *P* contained sodium hydroxide solution, copper sulphate solution, Millon's solution, three beakers, seven test tubes (four test tubes in a water bath and three separate test tubes.

Based on how the food test investigations were set-up (Figure 4), there were missed opportunities to develop science process skills. Firstly, the boxes stated the reagent or indicator used, the control, and the expected result for each food test investigation. For example, box S clearly states the colour change from "brown to blue-black" – this is a missed opportunity to develop the predicting and observing skills as the expected result is pre-determined and given to the learners.

The food test investigations were not carried out by the learners themselves, they watched the teacher demonstrate each investigation. Although one could argue that the learners developed the observing skill simply because they observed the investigations, another could argue that this is a missed opportunity for learners to develop not only observing but recording and interpreting skills. Learners were, however, required to highlight their observations on the practical handout. Figure 5 below shows the teacher, demonstrating the food test investigations while the learners watched.

Figure 5 Teacher Mercy demonstrating food test investigations*

At the start of each food test investigation, the teacher introduced each food test investigation either by stating the aim of the experiment or describing the indicator. This approach missed the opportunity to develop the experimenting skill in learners.

> Teacher Mercy: Ladies, we are going to be testing for carbohydrates. The only way we know how to test for carbohydrates is testing on polysaccharides because they have strong bonds. (S)

> Teacher Mercy: Now we are going to test for glucose. Glucose. There are two ways we test for glucose. So, ladies, experiment two we use benedict's solution. It looks blue. (G)
>
> Teacher Mercy: Lipids are easy, very quick experiment. Over here I have the sunflower oil that has been at school since 1972. You literally only use a drop. (L)
>
> Teacher Mercy: We obviously can't afford biuret solution with our school budget, but we can make it. So, what we do is we take 10% of sodium hydroxide it's an acid so I must make sure I handle it with care. I am using a 0.1ml solution, which translates to 10%. Then I also have my copper sulphate. It is blue. So, my biuret test will also be blue. You have to handle

it with care. I am going to mix it all up. It's going to be my biuret test. I am going to break the egg white. (P)

The teacher demonstrated food test investigations for starch and lipids following all the steps correctly. However, she incorrectly demonstrated the procedures for testing for glucose and proteins. Firstly, according to the practical handout, the test tubes were supposed to be placed in a boiling water bath, however there was no source of heat, as a result, the specimen was not heated as per instruction. Secondly, the teacher did not demonstrate correctly the procedure for making of the biuret solution. She gave an inaccurate explanation of the preparation method, she used incorrect units of measurement and incorrectly stated that sodium hydroxide is an acid, whereas it is a strong base. The lack of precision therefore did not offer full support for the development of science process skills particularly experimenting and identifying and controlling variables skills.

Teacher Mercy: Now we are going to introduce heat. Remember heat is a form of energy. Just like how we split hydrogen and oxygen from water using the sun light. I am going to imitate that process by introducing heat. We have a water bathing system here, there's no gas, we will have to get it re-gassed okay.

Teacher Mercy spent a lot of time attempting to link the theoretical knowledge to the practical work. The teacher using questioning to probe, however, most of the time she provided the answers to most of the questions posed. This is a missed opportunity for learners to develop their inferring skill.

Teacher Mercy's approach in the excerpt below is not taking into account the learners' existing prior knowledge. Her method of asking and answering her own questions does not give learners the chance to construct knowledge based on their observations. This indicates a lack of PCK.

Teacher Mercy: Who can tell me what is starch?

Learner: No response

Teacher Mercy: What is starch? Is it a monosaccharide? Is it a simple, does it give you energy right now? Imagine eating pap, does pap give you energy right now?

Learner: Indistinct response

Teacher Mercy: Definitely not a monosaccharide.

The teacher placed an emphasis on precautions to follow when carrying out food test investigations. The teacher attempts to develop the 'Handling apparatus' generic skill proposed by CAPS (DBE, 2011).

> Teacher Mercy: For this procedure ladies, one of the precautions to follow, okay, I am going to slice my potato or slice my bread. I need to make sure that I do it in a safe manner. (S)

> Teacher Mercy: The next procedure, iodine is very poisonous. We cannot touch it with our bare hands. (S)

> Teacher Mercy: Again, you must be wearing gloves and exercise in caution when we deal with chemicals in the lab. So, when you test for glucose, it will be brick-red. (G)

Table 8 summarises the occurrence of opportunities for the development of science process skills developed during food test investigations. The teacher managed to demonstrate two out of ten science process skills.

Table 8 Occurrence of science process skills during food test investigations

Science process skills	**Food test investigations**			
	S	**G**	**L**	**P**
Observing	✓	✓	✓	✓
Measuring	x	x	x	x
Inferring	x	x	x	x
Classifying	✓	x	x	✓
Predicting	x	x	x	x
Communicating	x	x	x	x
Controlling variables	x	x	x	x
Hypothesising	x	x	x	x
Experimenting	x	x	x	x
Data interpreting	x	x	x	x

Teacher Mercy demonstrated pedagogical content knowledge (PCK) by attempting to connect prior student knowledge with the food tests investigation in order to deepen learners' comprehension. She started by emphasizing the aim of each food test. Teacher Mercy used clear explanations and went through each food test step-by-step. She walked around the laboratory for learners to observe the colour changes. Key concepts like the necessity of heating Benedict's solution for sugar detection were not adequately covered, which resulted in knowledge gaps for learners. The teacher did not anticipate any misunderstandings that might occur. For example, learners thinking that glucose is a polysaccharide, resulting in widespread misunderstanding.

> Teacher Mercy: …You should always try to test first for glucose. What type of carbohydrate is glucose? Is it monosaccharide, disaccharide or polysaccharide?
>
> Learners: Polysaccharide.
>
> Teacher Mercy: Ladies, glucose is the most simplex sugar you can ever get. So, it is a monosaccharide.
>
> Teacher Mercy: Food test for glucose. It's a two-part experiment. We first going to test our monosaccharide, and then we are going to break down our disaccharide into a simpler form in order for the benedict's solution to work.

Teacher Mercy's practical lesson on food tests demonstrated poor constructivist teaching practices as it primarily depended on demonstrations rather than encouraging active learning and participation. Teacher Mercy led all four food tests investigations by herself, instructing her learners to observe without hands-on participation. There were little opportunities for learners to develop their science process skills such as hypothesizing, measuring, making predictions, discussing observations and making their own conclusions. Teacher Mercy provided direct answers instead of prompting her learners to think critically. Furthermore, the practical lesson fell short of incorporating collaborative learning, as learners were passive spectators rather than active participants in the learning process. Without opportunities for learners to develop their science process skills, the lesson did not demonstrate effective constructivist teaching practices.

Teacher Mercy employed the food test investigations as a teaching aid to facilitate learners' comprehension of content knowledge. She used various teaching strategies such as demonstrating, discussing, lecturing and note-taking. The aim of the food test investigations was not to develop science process skills. It seemed it did not provide any opportunities for the development of science process skills. Since the teacher only demonstrated the food tests investigations, one can argue that the observing skill was developed.

The food tests investigations were analysed through the lens of the science process skills approach, constructivism and pedagogical content knowledge (PCK). The study's results revealed the aim of the food tests practical work was not to develop science process skills. Despite the various teaching methods employed, such as demonstration, lectures, and note-taking, these approaches appeared to offer no opportunities for developing science process skills. However, the teacher demonstration seemed to develop the observing skill. This finding is consistent with Kandjeo-Marenga (2011) who found that teacher demonstrations in biology provide fewer opportunities (if any) to students for acquiring science process skills. In addition, the author discovered that teacher demonstrations were found to develop a few process skills, such as making observations, recording observed results, and writing conclusions. On the other hand, group experiments allowed learners to develop more science process skills. Therefore, teacher demonstrations provided little opportunity for the development of science process skills in learners.

The teacher used the food tests practical work to deepen conceptual knowledge. By observing how the teacher conducted the food tests investigation, the teacher spent a lot of time explaining theoretical concepts and eliciting prior knowledge. The teacher's subject knowledge was reflected well, however, the way in which she used the demonstrations reflected poor PCK as the demonstrations were teacher-centered.

The study found that there were little to no constructivist elements during the food tests practical work. In other words, the teacher did not use constructivist approaches that promoted the development of science process skills. This study's results contradict Vygotsky's (1978) social constructivist theory on which this study was anchored by. The theory posits that all mental functions initially emerge from social interactions, developed collectively through collaborative engagement with others, achieved through hands-on activities and group-work. Learners' involvement in the food tests practical work was less active, not clearly demonstrated in the study. The results showed that there were very little opportunities for science process skills to be developed by the learners as they took more of a passive role during the practical work.

In this section the researcher presents the results of the interview (see Appendix D) with the teacher about their planning of the lessons. The results showed that they did not plan the food test investigations with the intention to develop any specific science process skills accounting to the issue of time. According to the teacher Mercy, science process skills would be acquired indirectly during the food tests practical work. In other words, learners do not need to be explicitly taught science process skills step by step for them to develop. By simply conducting practical work for example doing experiments, observing, measuring and recording results learners would develop these skills.

As a follow up question, when asked to explain why they did not plan to develop science process skills in their lesson, the teacher answered that these skills are embedded in the curriculum so there she does not see the need to teach them explicitly.

Researcher: Which science process skills will be developed during the food test investigations?

Teacher Mercy: Because of time I will show the students how to do the experiments. They will have to watch what I do.

Researcher: Will you develop these skills when you have the opportunity?

Teacher Mercy: Not really, anyway we introduce science method skills in the first term then depending on the experiment we're doing some skills will be used. Also, the focus is on the theory than the skills.

The teacher added that usually they focus more on the content of the practical work not necessarily the skills. These statements confirmed what the researcher observed that there was very little opportunities for science process skills to be developed in learners. According to CAPS (DBE, 2011) science process skills should be acquired by the students for every topic taught.

Researcher: What are your views about the role of science process skills on concept learning?

Teacher Mercy: I think they are somewhat important but because of time, and too much content to go through it is difficult to develop each and every science process skill. In an ideal world students would have allocated lessons just for scientific skills.

The findings of the teacher's interview revealed that the teacher accounted to the issue of time for not providing any opportunities to develop science process skills. On the amount of time allocated for the orientation to Life Sciences for Grade 10 learners, which included developing some science process skills, CAPS (DBE, 2011) suggested 2 hours to complete this section. It is clear that the amount of time allocated for practical work, especially the development of science process skills was inadequate. Furthermore, the study found that the teacher recognised the value of science process skills in helping students grasp concepts but faces difficulties in developing and incorporating these skills due to time limitations and a heavy teaching workload. The teacher also believes that students need more opportunities to practice using science process skills in Life Sciences laboratory sessions. This finding is consistent with Gultepe (2016) who stated that all of the teachers expressed that lack of time due to a rigorous curriculum and an education system centred on national examinations was the primary obstacle encountered in developing science process skills in learners.

The teacher invested a significant amount of time in linking theoretical concepts to practical work. While the teacher uses questioning techniques to delve deeper, she often supplied the answers to most of the questions that were posed. This represents a missed opportunity for learners to develop their inferring skill. Gultepe (2016) argue in favour of the same finding by contending that most of the teachers the author studied prioritized concept learning more than the attainment of science process skills.

The teacher acknowledges the importance of science process skills in enhancing students' understanding of concepts, but due to time constraints and heavy teaching loads, they find it challenging to identify and implement these science process skills effectively. The teacher also felt that learners require more exposure on using science process skills in Life Sciences practical lessons effectively.

4.4 Which science process skills, if any, were assessed in the practical assessment task?

This section presents the practical assessment task (see Appendix E) in relation to the science process skills developed. It is important to note that the practical assessment task had questions that covered content beyond the topic of organic compounds. Although, the focus of the study was on science process skills that can be developed in the topic of organic compounds, all sections were analysed. The researcher decided to do this because the CAPS document indicates that the teacher can develop different science process skills in different topics. By analysing the whole task, the researcher could glean some of the science process skills that the teacher could have exposed learners to. Of the ten science process skills, seven process skills were evident in the practical assessment task.

Observing	The practical assessment task did not provide opportunities for development of observation skills
Classifying	This skill was present in Question 2.1 as learners were asked to classify which food type contained starch, glucose or protein. 9 out of 17 learners were able to classify the food types correctly. The rest of the learners were not able to classify each food type into the correct category.
Measuring	The practical assessment task did not provide opportunities for development of measuring skill.
Making inferences	*Learners were exposed to this* skill in Question 4.3 learners were asked to refer to the given graph and respond to how Chloe would know if the

investigation worked. The assessment did not use the term ‘infer’ or ‘inference’ in the question.

Predicting	Learners did not showcase this skill during the practical assessment task as it was not asked of them. A question asking learners to make a prediction could have been an opportunity to develop this skill.
Communicating	Learners were exposed to this skill in Questions 1.2 and 2.4 as learners are asked to explain functions of microscope and explain how one would go about testing for lipids. Most of the learners were able to explain and answer these questions correctly, however to develop this skill effectively, they should be given an opportunity during practical work to demonstrate this skill.
Interpreting	Learners were asked to state the relationship between temperature and sugar productions of amylase in question 4.5. Only one learner was able answer this question. The development of this skill relies heavily on the teacher’s planning and intentionally creating opportunities for the development of this skill.
Controlling variables	The skill was present in Question 4.2 as learners were asked to identify dependent, independent and controlled variables. Eight learners were not able to identify any of the three variables, five learners were able to identify only one of the three variables, and four learners were able to identify all three variables correctly. This shows that majority of the learners are not aware of the variables that need to be manipulated, and which ones need to be controlled.
Hypothesizing	The skill was not demonstrated by learners during the practical assessment task since it was not included. Asking learners to formulate a hypothesis could have provided an opportunity to develop their hypothesising skill.
Experimenting	Learners were not required to experiment during the practical assessment task. However, they were given questions regarding food test experiments that the teacher had demonstrated previously during practical work. They had to rely solely on memory to answer Questions 2.2, 2.3 and 2.4. Only two learners answered all three questions correctly and obtained 5 out of 5, four learners obtained 4 out of 5,

eleven learners obtained 3 or less out of 5. This proves that most of the learners did not develop this skill during the practical work.

Table 9 below shows the learners' results of practical assessment task out of 40 and their percentage score.

Table 9 Shows the results obtained by each learner

Learners	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mark out of 40	28	22	18	11	21	6	10	16	22	16	22	19	25	23	7	15	4
100%	70	55	45	28	53	15	25	40	55	40	55	48	63	58	18	38	10

The overall class average achieved by the learners was 42%. More than 50% of the learners obtained less than 50%. Only one learner obtained an average of 70%. Table 10 below indicates the average mark of the practical assessment task.

Table 10 Showing average mark of the practical assessment task

	Number of learners
0% - 10%	4
11% - 20%	2
21% - 30%	1
31% - 40%	4
41% - 50%	5
51% - 60%	1
61% - 70%	1

Learners achieved low scores in the practical assessment task, given that these skills were not honed during the food test experiments.

The primary objective of science education is to enable learners to develop science process skills (De Jager, 2001). It is therefore crucial to determine whether students acquire these skills or not. Firstly, literature revealed that most research studies measured science process skills with multiple-choice tests (Sıbıç & Şeşen, 2022). The current study found that the practical assessment task was more theoretical than practical based. Secondly, it also found that, it did not measure most of the science process skills that could have been developed during food tests practical work. This is comparable to the findings of Sıbıç and Şeşen's (2022) study where they examined science process skills tests in Turkey and discovered that some science process skills were measured more frequently than others.

The study's results showed that learners performed poorly in the practical assessment task, as they had not developed the science process skills through the food tests practical work. However, this finding was in contrast with the observation made by Ping et al., (2019) although the authors focused on argumentation instruction through practical work on science process skills, learners who were exposed to explicit teaching of science process skills performed better than learners who were not. Another study by Apeadido et al., (2024) discovered that incorporating practical work into the curriculum led to a consistent rise in students' proficiency in science process skills, accompanied by notable enhancements in academic achievement due to the practical work.

4.5 Conclusion

This chapter presented and discussed the findings of the study by answering each of the research questions. The findings presented in this chapter have shown that the CAPS document (DBE, 2011) highlights the importance of practical work and that learners are expected to develop science process skills in Life Sciences. The results also showed minimal evidence of constructivist components during food tests practical work as learners played a more passive role, in other words, the teacher did not use constructivist approaches that promoted the development of science process skills. Although the teacher acknowledged the importance of developing science process skills in learners, it was found that there were challenges in developing these skills due to time limitations and heavy teaching loads. The practical assessment task results suggest that learners underperformed reflecting gaps in their practical work and development of science process skills. The next chapter draws conclusions from the study, offers recommendations, limitations and implications of the study.

Chapter 5

Conclusion, recommendations, limitations and implications of the study

5.1 Introduction

The previous chapter discussed the findings of the study. This chapter presents the conclusion, recommendations, limitations and implications of the study. The focus of this study was investigating the opportunities for developing science process skills in learners during the food tests practical work. The study explored whether science process skills can be developed through food tests practical work, how food tests investigations were carried out and finally which science process skills, if any, were assessed in the practical assessment task. The main aim of the investigation lies in the research question:

How does practical work in food tests provide the opportunities to develop science process skills in learners?

The CAPS document (DBE, 2011) and the practical handout used by the learners during the practical work were analyzed. The video recording of the practical lesson was transcribed and the teacher's interview were conducted by the researcher at the selected school situated in Johannesburg, South Africa.

5.2 Overview of the study

This study is made up of five chapters which were developed to respond to the research questions of the study. The summary of the chapters is organised as follows:

Chapter One:

This chapter outlines the rationale of the study, highlighting the background to the study. The study also emphasizes the research problem and research question, identifying the significance and limitations of the study. The main aim of the study was to investigate whether food tests practical work provides the opportunities to develop science process skills in learners. This chapter's groundwork served as a foundation for the chapters to follow in the study.

Chapter Two: This chapter primarily focused on the review of literature on science process skills that are developed during practical work. The researcher delved into literature focusing on the development of science process skills. Researchers found that it was important for learners to develop their science process skills as part of their scientific expertise. The literature reviewed practical work's significance, its role as a teaching and learning strategy, and any advantages and challenges to incorporating practical work in a Life Sciences classroom. Literature revealed that incorporating practical work as often as possible had a positive impact on learners' academic achievement. It emerged that practical work provided an opportunity for both learners and teacher to make learning applicable in everyday experiences; learners being motivated to learn Life Sciences as well as improvement of learners' understanding and knowledge of abstract concepts in Life Sciences. On the other hand, it emerged that there are a few challenges to implementing practical work in teaching and learning Life Sciences. These include the lack of resources, pedagogical knowledge, heavy workloads and time constraints.

Chapter Three: This chapter discussed the research methodology, research paradigm, participants of the study, data collection instruments, data collection and data analysis techniques used to get the research findings. The study used a variety of data sources approach to collect data. The data was collected using qualitative methods, including a video recording of the practical lesson and the participant interview.

Chapter Four: This chapter presented the results the study and the discussion of those findings. The findings revealed that there were little opportunities for science process skills to be developed in learners during the food tests practical work.

Chapter Five: This chapter presented the conclusion, recommendations, limitations and implications of the study.

5.3 Summary of findings

Research indicates that when learners are unable to conduct practical work due to constraints such as limited resources, teacher-led demonstrations can be effective. However, even though the participating school was well-resourced and had a fully functional laboratory, the teacher used the demonstration approach to conduct food tests practical work. The findings indicate that reliance solely upon teacher demonstrations is likely to reduce the opportunities of the development of science process skills leaving learners at a disadvantage. The interactions between the teacher and her learners were teacher centred. Evidence showed that the teacher spent most of the time eliciting conceptual knowledge rather than the development of science process skills.

The interview with the participating teacher suggested that she did not develop science process skills due to time constraints. Even though their views on the development of science process skills were positive.

In the practical assessment task, an overwhelming majority of learners could not identify the reagents used for each food test. Even though the teacher had already conducted the demonstrations on food tests with her learners, they could not explain what they saw or what had been done during the food tests practical work. The assessment also revealed that very few of the learners could not explain the basic procedures such as setting up a water bath for some of the food tests. The questions from the practical assessment task show that the opportunities for the development of science process skills were very low, considering the type of questions asked.

The study found that there were several opportunities for the development of science process skills while carrying out practical work in the teaching of food tests in Life Sciences. Basic sciences process skills such as observing, comparing, predicting, and measuring may have been developed during food tests practical work. Integrated science process skills such as constructing tables and graphs, formulating hypotheses and experimenting could have been developed during food tests.

5.4 Implications of the study

This study has implications for teachers, subject advisors and subject specialists from the Department of Basic Education. The study revealed that there are little opportunities of developing science process skills during food tests practical work. Since that is the case, learners achieve low marks in practical assessment tasks as their science process skills are not developed.

After visiting the school, the researcher found that although the school has a functional laboratory with adequate resources, these were not taken advantage of. Teachers need to make an effort to providing opportunities for learners not only to carry out practical work in pairs or group work but to develop science process skills while doing so. Heads of department need to make sure that schools use their resources fully so that learners benefit from them. During practical work, teachers should pair or group learners instead of demonstrating the work for the learners, which could enable learners to deepen their scientific knowledge and develop science process skills at the same time.

The teacher made no attempt to develop science process skills in learners. To address this, teachers require professional development especially in the developing of science process skills in Life Sciences learners so that teachers are confident and positive in developing these skills in the classroom.

5.5 Limitations

The study focused on one teacher who facilitated practical work to one class of Grade 10 learners. Therefore, the findings of this study cannot be generalised as only one teacher in one school was involved and only limited to the topic of food tests.

5.6 Recommendations

The key recommendations that arose from the study's findings are as follows:

1. Teachers should avoid teacher-centred practices in the science classroom as they reflect poor Pedagogical Content Knowledge.
2. On the aspect of assessment, teachers should assess learners' ability to apply science process skills instead of theory-laden assessments.
3. School principals should allocate more instructional time on the timetable for practical work so that teachers have the time to develop science process skills.
4. There is a need for the Department of Education (DBE) to provide specialised training or workshops to improve teachers' understanding of science process skills so that they are able develop these skills in learners.

5.7 Areas for future research

Arising from the research findings of this study, some other aspects of this study area may not have been studied, and these areas may need to be studied include:

- Research into the perceptions of learners in the inculcation of science process skills in Life Sciences.
- Future research could explore the effectiveness of practical work on learners' acquisition of science process skills.

5.8 Conclusion

The study has investigated the opportunities for developing science process skills in learners during food tests practical work. The literature reviewed showed that science process skills are important because they enable learners to engage actively in practical work. These skills include observing, hypothesizing, experimenting, collecting and analysing data and drawing conclusions equip learners with the ability to investigate science phenomena. The study revealed that the Curriculum and Assessment Policy Statement (CAPS, DBE, 2011) stipulates that practical work is integral to science education and not optional, requiring that a significant portion of instructional time be dedicated to scientific investigations. CAPS (DBE, 2011) further highlights that science process skills are to be developed while carrying out scientific investigations. The study found that although practical work was included in the curriculum, its implementation was not structured in a way that promoted the development of science process skills in learners.

During the practical work, learners played a more passive role because the teacher demonstrated all the food tests, which limited the learners' engagement. The findings suggest that while the practical work exposed the learners to the scientific investigation procedures, it was not done in a way that promotes the development of science process skills which are necessary for scientific inquiry. Furthermore, the teacher's incorrect demonstration of certain procedures such as preparing the biuret solution, contributed to the missed opportunities for learners to develop their measuring and experimenting skills. While the use of the practical handout allowed learners to read the instructions and record their results, this was not sufficient to foster skill development. Furthermore, evidence from the practical assessment task revealed that many learners struggled to answer questions that required the application of science process skills such as formulating hypothesis, interpreting results or drawing conclusions from data.

In summary, this study found that practical work delivered in a limited and procedural manner does not inherently provide opportunities for the development of science process skills in learners. To develop these skills, practical work needs to be carefully organised and intentionally structured to promote science process skills such as observing, classifying, measuring, making inferences and drawing conclusions. Teachers play a critical role in creating opportunities for the development of science process skills during practical work. If such deliberate efforts are not undertaken, practical work may become a superficial exercise rather than a meaningful tool for developing scientific literacy.

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List of Appendices

Appendix A: CAPS document (DBE, 2011)

2.5.2 Specific Aim 2: Investigating Phenomena in Life Sciences

Learners must be able to plan and carry out investigations as well as solve problems that require some practical ability. This ability is underpinned by an attitude of curiosity and an interest in wanting to find out how the natural world and living things in it work.

The following range of skills relates to **doing** practical work in Life Sciences. All seven skills will not apply to every activity equally. The skills are aligned to what learners would be doing in the normal course of carrying out an investigation. Teachers must select those skills that apply to and can be assessed in the context of specific activities. By the end of the Grade 10 year, all seven skills must have been assessed at a **grade-appropriate** level.

Note: While **doing** practical investigations involves a specific range of skills, learners' knowledge on and understanding of science can, and should, be assessed within the context of the cognitive domains of Specific Aim 1.

Learners must be able to:

2.5.2.1 Follow Instructions

This is essential, especially in the lower grades and in large classes. Teachers cannot expect all learners to use unfamiliar equipment and to do so independently without giving them a clear set of instructions to follow. The amount of assistance required would indicate the level of performance in this regard. Adherence to safety rules should be part of this.

2.5.2.2 Handle Equipment or Apparatus

This should include having knowledge of the apparatus, that is, being able to name it and knowing what it is used for. The learner should be able to use different kinds of equipment. 'Handling equipment' is a generic skill and applies to any equipment used for many different kinds of investigations. Handling improvised equipment requires the same skills as would be required for handling standard laboratory equipment. The emphasis is on **using** equipment appropriately and safely (and not on only memorising the names of apparatus).

2.5.2.3 Make Observations

A variety of observations are possible and observations can be recorded in different ways, such as:

- drawings;
- descriptions;
- grouping of materials or examples based on observable similarities and/or differences;

- descriptions;
- grouping of materials or examples based on observable similarities and/or differences;
- measurements;
- comparing materials before and after treatment;

- observing results of an experimental investigation which will involve recording information in an appropriate way; and
- counting.

2.5.2.4 Record Information or Data

This should include recording observations or information as drawings, descriptions, in simple table format, as simple graphs, etc. The skill of 'recording' is transferable across a range of different scientific activities.

2.5.2.5 Measure

Learners should know **what** to measure, **how** to measure it and have a sense of the degree of accuracy that is required. A variety of things could be measured including (but not limited to) length, volume, temperature, weight or mass and numbers (counting). Measuring is a way of quantifying observations and in this process learners should learn to make estimations.

2.5.2.6 Interpret

Learners should be able to convert information from one form, in which it was recorded, into another, for instance converting a table into an appropriate graph.

Learners should be able to perform **appropriate** simple calculations, to analyse and extract information from tables and graphs, apply knowledge of theory to practical situations, recognise patterns and/or trends, appreciate the limitations of experimental procedures as well as make deductions based on evidence.

2.5.2.7 Design/Plan Investigations or Experiments

Not all investigations are based on the 'classic' dependent-independent variables and controls. For example, an investigation could involve observing soil profiles or counting populations.

Designing an investigation is a different process to planning an investigation. In the design process options need to be considered in terms of the hypothesis and variables may have to be identified.

Skills include:

- identifying a problem;
- hypothesising;
- selecting apparatus or equipment and/or materials;
- identifying variables;
- suggesting ways of controlling variables;
- planning an experiment;
- suggesting ways of recording results; and
- understanding the need for replication or verification.

In Grades 10, 11 and 12, learners must be able to plan and/or design a simple investigation or experiment.

Note: Skills 2.5.2.1-2.5.2.6 (following instructions, handling equipment, making observations, recording information, measuring and interpreting information) are all required, in one form or another, to carry out an experiment or investigation. By separating seven different kinds of skills (2.5.2.1-2.5.2.7), these skills can apply to the **variety** of practical work that is appropriate for a particular grade in Life Sciences, including simple investigations or experiments. This approach makes it easier to assess learners in a range of different circumstances and it enables a teacher to judge a learner's ability to **do** science. The skills are based on what learners will be doing actions during the normal course of doing practical work. However, there are some circumstances in which only some of these skills would apply and not every skill can be assessed in every practical task.

TERM 1	
Time	**Orientation to Life Sciences: Subject Orientation**
½ **week** **(2 hours)**	Establish links between Natural Sciences (GET) and Life Sciences (FET). Define life, its scope, and its continuity. Life on Earth is dynamic, with homeostasis maintaining balance at every level of organisation. Life is characterised by changes over billions of years. Living systems exhibit levels of organisation from molecules to biomes. The nature of science: science involves contested knowledge, and non-dogmatic inferences based on evidence and peer review. **How Science Works:** Science is based on: • fundamental knowledge built on scientific evidence and verified findings (articles that are published in journals or at conferences: peer review); • observing; • investigating; • making measurements and understanding the importance of scaling; • collecting and presenting data in the form of drawings, written descriptions, tables and graphs; • understanding the limitations of scientific evidence; • identifying patterns and relationships in data; • communicating findings; and • taking societal aspects of scientific evidence into account. Scientific skills involve: • importance of biological principles such as relationship between surface area and volume/size, the relationship between structure and function • biological drawings: principles that apply • translating 3 dimensional objects or specimens into 2 dimensional drawings and photographs and interpreting 2 dimensional drawings and photographs: transverse and longitudinal sections • general introduction to the range of skills listed under the Specific Aims that must be developed • introduction to graphs: different kinds of graphs and when to use them; interpreting graphs. • calculating
	Organisation of learning and rules include: • using equipment and other resources; • understanding procedures and how to safely use apparatus in laboratories and classrooms; • working in groups; • understanding assessment requirements; and • a very brief mention of careers and subject combinations for entrance to higher education

TERM 1				
		Organic Compounds • carbohydrates - monosaccharaides (single sug e.g., glucose and fructose; disaccharides, (double sugars), e.g., sucrose and maltose; polysaccharides (many sugars), e.g., starch, cellulose and glycogen; • lipids (fats and oils) - 1 glycerol and 3 fatty acids: unsaturated and saturated fats; cholesterol in foods; and heart disease *(link to Grade 9);* • proteins - amino acids (C,H, O and N and some have P, S, Fe) - are sensitive to temperature and pH: loss of structure and function; the role of enzymes in breaking down/synthesising molecules; the influence of temperature and pH on enzyme action; the Lock and Key Model of how enzymes work; enzymes in everyday life (for instance using washing powders); • Mention of nucleic acids - DNA and RNA - consisting of C, H, O, N and P (no details of structure required); and • vitamins - e.g., A, one of the B vitamins, C, D and E. *(Simple diagrams to represent molecules. Review briefly why these substances are needed in plants and animals i.e. build on prior knowledge. Do not give detail of structure or function - functions will be dealt with in later sections where appropriate. This is a brief introduction to the molecular make-up of organisms.)*	**Essential:** • Food tests for starch, glucose, lipids and proteins. • Investigate the working of a 'biological' washing powder (containing enzymes). OR • Hydrogen Peroxide and chicken liver to demonstrate the effect of enzymes. OR • Fresh pineapple juice and solid egg white in a plastic drinking straw. AND • Observe, measure and record results of the experiment done at different temperatures. • Compare the Recommended Daily Allowance (RDA) with usual diet of individual learners. Draw a pie chart of the food types and discuss implications of the usual diet of learners.	• Chemicals • Bunsen burners • Thermometers • Washing powder • H_2O_2 and chicken liver or • Pineapple juice, egg white and plastic drinking straws

Appendix B: Practical Handout

1. Food test for starch

Aim: To find out if starch is present in the given types of food.

Apparatus/Chemicals:

1. Ten medium sized test – tubes (preferably ±10 cm tall or a test plate (white).
2. Scalpel or razor blade
3. Dropper
4. Materials: Small amounts of different food stuffs (preferably the ones easily available to you (what learners use everyday), e.g. Carrot, rice, grapes, onion, potato, tomato, sweet potato, peanut, small pieces of pumpkin, egg white.
5. Reagent: Freshly prepared iodine solution.

(Iodine solution freshly prepared by mixing equal amounts of iodine crystals (I_2) ½ a spatula) and potassium iodine (KI). Dissolve this mixture in 20ml of water. Put this iodine solution in an amber bottle so that you may use it even in future.

Method:

- Cut a small piece from each of your food stuffs and put each piece in a separate cell of your test plate or test tube.
- For your control put half a spatula-full of starch powder in one of the cells of your test plate/test tube.
- Use the dropper to put one drop of the iodine solution on each of the types of food.
- Leave the experiment for 30 seconds without disturbing the test plate/test tubes.
- Observe the results: Observe the colour of each type of food and compare it to the colour change of starch after adding iodine solution.

Precautions:

1. Do not leave the bottle containing iodine open because iodine (I_2) sublimes (changes from solid to vapour once exposed to air).
2. Make sure that the iodine solution is not exposed to direct sunlight; hence you are instructed to keep it in an amber bottle.
3. Make sure that there is no spill over of the liquid from any of the test plate cells.
4. Avoid touching iodine crystals and iodine solution with your bare hands.
5. Do not include any processed food among the type of food you are testing. Examples: processed food; bread, yoghurt, cakes, viennas etc.

2. Food test for glucose

Aim: To demonstrate the presence of glucose.

Apparatus/Chemicals:

- 2 test tubes
- 1 beaker
- A burner
- Glucose solution
- Sucrose solution
- Benedict's solution

Precautions:

- Ensure that it is safe to use a flame.
- When boiling ensure that the mouth of the test tubes points away from people.
- Use a test tube holder and wear goggles.

Method:

- Half fill the beaker with water and boil it.
- Label test tubes as A and B
- Quarter fill test tube A with the glucose solution.
- Quarter fill test tube B with the sucrose solution.
- A few drops of Benedict's solution are added to each test tube.
- Observe and record the colour in the table below.
- Place the test tubes into the boiling water bath, lower the flame.
- Wait for 5 minutes then observe and record the colour of the solutions.

Conclusion:

On heating the change of colour from blue to green to yellow and orange/ brick red indicates the presence of glucose.

3. Food test for lipids

Aim: To develop a test for determining whether or not fats and oils are present.

Apparatus/chemicals:

Ethanol (ether)

Cooking oil

2 small test tubes

Filter paper (or blotting paper)/brown paper/news paper

Method:

1. Add 5ml of ethanol (or ether) to each of the two small test tubes.
2. Add two to three drops of cooking oil in one of the test tubes. Shake thoroughly until the oil dissolves.
3. Put a drop of the oil in ethanol solution on a piece of filter paper (or blotting paper). Mark the position of the drop. This is your experiment.
4. Put a drop of pure ethanol (or ether) on another piece of filter paper. Mark the position of the drop. This is your control.
5. Leave the filter papers out to dry for a few minutes.

Conclusion

Since only fats and oils leave behind a grease spot stain on filter paper, the test can be used to determine whether or not an unknown substance contains fats and oils.

TEST FOR PROTEINS USING THE BIURET TEST

Aim: To show if proteins are present or absent in a biological compound.

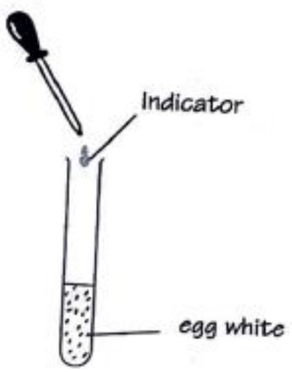
Apparatus/Chemicals:

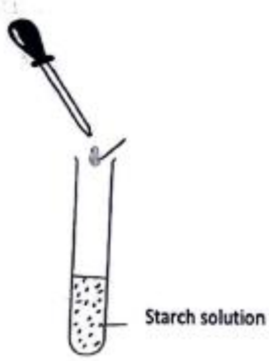
- Two test tubes
- Two beakers
- Water
- Spatula
- Medicine droppers
- Egg white
- Starch

NB. The biuret test is made by mixing a 10% sodium hydroxide solution with a few drops of 1 % copper sulphate solution.

Method:

1. Mix some egg white with water in a beaker. Stir the contents using a spatula.
2. Quarter fill test tube T_1 with the egg white solution and test tube T_2 with starch solution.
3. Using a medicine dropper add 2-3 drops of biuret solution to test tube T_1 and to test tube T_2. Gently agitate both the test tubes to mix the contents.
4. Note the colour change in the test tubes.





Discussion:

Buiret solution is a blue liquid that changes to purple when proteins are present and to pink in the presence of short chains of polypeptides. The copper atom of the biuret solution reacts with the peptide bonds to cause the colour change.

Conclusion:

When a protein is present, the colour purple indicates a positive test, e.g. test tube T_1.

Appendix C: Video recording of the practical lesson

Food test 1: Observations for testing for starch using iodine

Time	*Speaker*	*Teacher classroom actions*	*Observation*
0:31	T1	"Ladies, we are going to be testing for carbohydrates. The only way we know how to test for carbohydrates is testing on polysaccharides because they have strong bonds."	Teacher describes the aim
1:13	T1	"What you need to know is the outcomes of food test. You need to know the reagent that we use in order to test positivity, you also need to know the colours changes, very important, as well as safety procedures that you need to follow."	Teacher outlines which reagent will be used and what to note for each practical.
2:00	T1	"You have received a booklet, please make sure you read through it at home. You will be given a PAT (practical assessment task) where we will question you on the procedure, colour changes and the reagent that we will be using to test for positivity of our biochemical molecules."	Teacher asks learners to read the hand-out at home.
	T1	"For this procedure ladies, one of the precautions to follow, okay, I am going to slice my potato or slice my bread. I need to make sure that I do it in a safe manner."	The teacher demonstrated how to slice potato
	T1	"The next procedure, iodine is very poisonous. We cannot touch it with our bare hands."	Teacher elicits previous knowledge by asking for prior knowledge. Teacher is giving theoretical background
	T1	"Who can tell me what is starch?"	
	Learners	No response	
	T1	"What is starch? Is it a monosaccharide, is it a simple, does it give you energy right now? Imagine eating pap, does pap give you energy right now?"	
	Learners	Indistinct response	
	T1	"Definitely not a monosaccharide"	
	Learners	"It is a polysaccharide"	
	T1	"Thank you. It is a polysaccharide. But the basis of starch. Where does starch come from? Remember photosynthesis. Let us think of the photosynthesis equation. Let's think of the	

		reactants, what is required to get to the products of photosynthesis? What do we need?"	
	Learner	"Light."	
	T1	"Obviously, light is a form of radiant energy. We need the energy in order to kick start the photosynthetic reaction. Next what do we need?"	
		Indistinct response	
5:15	T1	"Water! Where do plants get water from?"	
5:23	Learners	"The roots"	
5:25	T1	"The roots. So, we get water as a minerals from the soil. Then they will come up via the roots. Through the xylem. We will be doing cells so now I am bringing up these concepts so that you can understand what we are going to do when we do cells. [goes on to explain vascular tissue of plant, xylem and phloem] Ok what's next?"	
6:10	Learners	Indistinct chatter	
6:20	T1	"We need carbon dioxide. And carbon dioxide is what? Is it a gas, liquid or solid? Where do we get it from? From the air, from the environment. So that's the things you need to be thinking about when we are doing such tests. When we are doing theory, when we coming to products of different chemical reactions in biochemistry. So, with radiant energy, that energy breaks apart the bonds between carbon dioxide and water. So, what is our products?"	
	Learners	"Glucose and oxygen."	
7:12	T1	"Dankie! Glucose and oxygen. So, when you are looking at photosynthetic chemical reactions, you have to look at reactants and products. So, our products in this case, from photosynthesis, is glucose and oxygen. Ok now, does plants use glucose?"	
7:44		*Silence*	
7:50	T1	"Why would I make something that I am not going to use?"	

8:10	Learners	"Yes!"	
8:12	T1	"Yes because of cellular respiration but plants use what they need, just like you can't eat a whole pot of pap. You have a portion of food that you eat every day. So, does photosynthesis stop? If the plant is okay with glucose, the sun is out, will photosynthesis stop?"	
	Learners	"No." *(Learners seem unsure)*	
8:52	T1	"No, it is not going to stop okay. So, the plant has used up its glucose for the day. Remember, it's food for them. It has used up the glucose for the day. So, what happens to that excess glucose? It gets…"	
9:20		Learners mumble. Finally, one learner says "It gets stored as starch."	
9:30	T1	"It gets stored as starch. What starch products do you know that come from a plant?"	
	Learners	"Potato."	
9:49	Teacher	"I have my potato here (teacher waves potato). This is a starch deposit. Plants deposit their starch vegetatively, they also deposit their glucose and…" (expects response from learners	
10:04	Learners	Silence	
10:07	T1	"Fruits! It is not sweet. Fruits are higher in glucose. Vegetables are higher in starch."	
12:00	T1	"In order for us to test for starch. Starch is a form of a polysaccharide. It has extremely strong bonds. Here I have starch. A white powder. Safe to use. It looks like flour. I have a piece of white bread. It is high in carbohydrate. Then I have a potato. I am going to use a scalpel in order to cut, I am not really going to dissect but that is the function of a scalpel. I am going to use a petri dish in order to hold my specimen, then I have a spoon to scoop up my starch, then I have iodine I will handle it with care. Who knows what the original colour of iodine is?"	The teacher demonstrates how to test for starch.
13:23	Learner	"Brown"	
13:26	T1	"Orange- brown. Now I am going to carefully cut a piece of my potato… into my petri dish."	Teacher cuts the potato using a scalpel

	T1	"Here is my piece of potato. Then I am going to use a dropper. How do I use a dropper? I squeeze, then emerge into my solution, then I let go, then the solution will collect in the chamber here. I carefully open the iodine, make sure not to spill. Then again. I squeeze. I immerse. Liquid collects in my chamber. Then I will take my petri dish. I am going to put a couple of drops. Can you all see that? I am going to put a couple of drops on my potato. Can you please note that the colour is orange brown. I am going to drop it onto my potato. Then I wait a couple of seconds. Then you can see the colour change. It is turning black. (Walks around the class to show the learners)"	
15:55	T1	"You must make notes ladies. Don't just look at it. You will not remember. So ladies, my outcomes. My results, not my discussion. What am I observing. What have I observed? *(Learners mumble)* A colour change! What is my colour change? From orange-brown to blue-black. That is th e result. What you are observing. I just gave you introduction on how starch is made. Now we are going through our method and materials. Now we are going through results. Your results are what you see. Don't tell me if it's a positive or negative. That is in your discussion. Results you are giving data. My data is that it has change from orange-brown to blue-black. My conclusion is that it has a positive indication for starch. That is your conclusion."	Learners make notes in the hand-out
17:27	T1	"Then I am going to take the piece of bread. And do the same thing. Drop drop drop." (Walks around the class)	The teacher shows the learners the results.
18:00	Learners	"Turns blue-black." (Learners mumble)	Learners respond
	T1	"Good. It turns blue-black. So, what is my results ladies? It went from?"	
	Learners	"Brown to blue-black"	
	T1	"So, what is my conclusion? Positive indication for starch. Well-done. That is how we test for starch. We always use iodine. The reagent for experiment one, is iodine!"	The teacher confirmed the results and concluded.

Food test 2 Observations for testing for glucose using Benedict's solution

18:40	T1	"Now we are going to test for glucose. Glucose. There are two ways we test for glucose. So, ladies, experiment two we use benedict's solution. It looks blue."	The teacher explains the aim of the activity to the learners.
19:24	T1	"Oh no, I forgot to show you starch." (Quickly drops iodine solution on starch powder)	The teacher demonstrates test for starch *(Part 1)*
	T1	"Experiment two. Benedict's solution. So, ladies, with this experiment. You should always try to test first for glucose. What type of carbohydrate is glucose? Is it monosaccharide, disaccharide or polysaccharide?"	The teacher explains the concepts of carbohydrates
	Learners	"Polysaccharide."	
	T1	"Ladies, glucose is the most simplex sugar you can ever get. So, it is a monosaccharide."	
21:10	T1	"Food test for glucose. It's a two-part experiment. We first going to test our monosaccharide, and then we are going to break down our disaccharide into a simpler form in order for the Benedict's solution to work."	The teacher explains the aim of the activity to the learners
21:28	T1	"So now glucose ladies, it has... uhm maybe you have done it before... chromo... something in Grade 7."	The teacher tries to draw from previous knowledge
		Learners seem confused.	
	T1	"Where you separate the different colours in a solution. Do you remember that?"	
	Learners	"No ma'am."	
	T1	"When you are doing mixtures. When you use a sieve, filter, use heat… all of that. So, with glucose, when you are testing a substance for glucose, you are going to have different colours. So, the simplest form of glucose, you will always get it at brick-red. Positive test for glucose is brick-red. Negative test for glucose is blue because Benedict's solution is blue. When you have other forms of carbohydrates, from monosaccharides, brick-red to disaccharides you will get yellow-brown" *(Shows learners different test tubes with different colours).*	
22:44	Learners	"Ma'am positive test is?"	

	T1	"Brick red."	
	T1	"Yes. That is your conclusion. When you get disaccharides, it becomes yellow, another high chemical bond, so your "polys" will be green, when it's like pap it will stay blue. This is the colour change for glucose. So, the first part is to test for glucose. You put your glucose in a test tube, then you put the Benedict's solution."	
	T1	"Again, you must be wearing gloves and exercise in caution when we deal with chemicals in the lab. So, when you test for glucose, it will be brick-red."	Teacher reminds learners of safety precautions in the laboratory
24:07		"Then when we have a disaccharide. It will look like this. *(Showing orange test tube)* but we know it is a carbohydrate molecule. So how do we break down a disaccharide? In order for us to test it if it is a sugar. On YouTube they usually say a reducing sugar. Your reducing sugar would be glucose. Your non-reducing sugar would be disaccharide."	
24:48		"So, if I want to break down my disaccharide, I need to make sure that I break down the bonds, in order to make it a simple sugar. So, what do I do? I have a test tube, here is the brick red result" (shows learners the test tube).	
26:15	T1	"Now we are going to introduce heat. Remember heat is a form of energy. Just like how we split hydrogen and oxygen from water using the sun light. I am going to imitate that process by introducing heat. We have a water bathing system here, there's no gas, we will have to get it re-gased okay."	
26:47	T1	"We are going to put it underneath here. The precaution is that make sure that nothing flammable is around here, because it might cause an explosion in the lab. You have to have adult supervision in order to make sure that you are responsible enough."	
27:09	T1	"I am going to use a water bath, it's just a beaker with water in it. And then I'm going to put the original, clear test tube with pure sucrose, here is my sucrose (walks around to show the learners), basically it looks like sugar."	

28:08	T1	"I am going to have a clean test tube, I am going to put one scoop of sucrose in the test tube. Then I am going to allow it to boil. As it's boiling, the bonds are breaking. Again, this beaker is hot, the test tube is hot, I must handle with care, so I'll have gloves on. So when it is warm enough I am going to put my Benedict's solution using my pipette. Then after some time is it going to turn brick red. That's how you test, break down disaccharide you need to introduce a water bath to break down the chemical bonds in order for us to test for glucose and we will end up with a brick-red test tube"	

Food test 3: Observations for testing for lipids using filter paper

29:39	T1	Lipids are easy, very quick experiment. Over here I have the sunflower oil that has been at school since 1972. You literally only use a drop. Look at me opening it, then you'll know it has been here since 1978	The teacher explains the aim of the activity to the learners.
	Learners	Learners are amused	
30:20	T1	Here, I am using a plant product. What type of oil do we get from plants? Is it saturated or unsaturated?	
30:45	Learners	Saturated	
	T1	Plants products is it saturated or unsaturated? They are unsaturated. These are healthy fats. There's also been research that says butter is healthier than margarine. For the purpose of your syllabus, they still think that butter is bad for us.	
31:24	T1	We are going to use sunflower oil, I also have peanuts.	
31:32	T1	Again, do not eat this. Whatever enters the lab, you can't eat. The chemicals might have accumulated here, then you come and eat it and you die.	
31:46	T1	We have ethanol of 96%, definitely you can't drink this. You are going to die. Your hand sanitisers have ethanol in it. And you don't drink hand sanitiser. (Goes on about epithethial being form of protection whereas inside our bodies there's no protection from harmful substances).	
33:42	T1	We use ethanol because it evaporates very quickly, and you can clearly see fat deposits. I also have filter paper. We will have to hold up the filter paper against the sun	

		so we can see the spots left behind by fat. Very simple test, you can do it at home.
34:45	Learners	*Learner tells funny story about sanitiser and fire.*
35:07	T1	I have two filter papers. For one, I am going to test for fats and lipids with peanuts and test for fats and lipids with sunflower oil. I have my dropper, I will take my sunflower oil. I am going to put it on to my filter paper, without ethanol. Can you see the spot. Then I am going to use my other dropper. We don't use same dropper. Remember I cannot use the same apparatus for different chemicals. Because you will contaminate your investigation.
37:12	T1	I will use a new dropper in the ethanol, away from your nose, or you will get high. I am going to wait for it to dry out.
		I am going to take one of my peanut. I will rub it on there (filter paper). Here is my rubbed in peanut (walks around to show filter paper with oily spot). I will put in ethanol on it. I will wait for it to evaporate.
38:14		The rate of reaction, one thing you need to know, it is always good to note how the surrounding environment is it cloudy, is it sunny, is it windy, is calm, is it filled with humidity or is it very dry. All these environmental factors can change your results. I am busy talking, talking, talking here because it is winter, so it is going to take a little bit of time for it to react. So one of the environmental factors is that it is cooler than normal, so my ethanol… and also there's no wind in here, so my ethanol is going to take a bit of time to evaporate.
39:24		While we wait, let me demonstrate for you the other food test. The next one is proteins, experiment number four. Big letter biuret test.

Food test 4: Test for protein using sodium hydroxide and copper sulphate

40:31	T1	We obviously can't afford biuret solution with our school budget, but we can make it. You take 10% of sodium hydroxide. I am using a 0.1%ml solution, which translates to 10%. Then I also have my copper sulphate. It is blue. So, my biuret test will also be blue. You have to handle it with care. I

		am going to mix it all up. It's going to be my biuret test. I am going to break egg white.
	T1	Not so much the egg yolk because that's full starch, full of peptides, sorry no polysaccharides. So, the egg whites are full of proteins.
42:39		Teacher mixes the biuret solution
43:04	T1	I will put the egg white in the test tube, then I will take my dropper I put it inside the test tube. If it turns … (quickly checks the notes), if it turns blue, because egg white is a clear to blue is a negative test for proteins.
43:50	T1	Then the same with glucose ladies, remember we have monosaccharides, disaccharides and polysaccharides. With our proteins we have mono-peptides, bi-peptides and polypeptides. The only time you call something protein if it has fifty plus mono-peptides. So please make an indication in your experiments that it's only called protein if it has fifty mono-peptides in a chain. It is very important especially for next year. If it is less than fifty then we refer it as polypeptides.
45:30	T1	If I have a mono-peptide, it will turn… (reads notes), if you have a mono-peptide and di-peptide it will turn rose pink colour (waves test tube in the air for learners to see). Please write that down.
46:59	T1	Now look at this blue solution (waves in the air for learners to see), if it is a large protein equals purple/violet.
47:33	T1	So, ladies, in addition to this when you are testing your mono-peptides, di-peptides we do not have to introduce a water bath, when it is a large protein, we need to make sure that those bonds break down just enough so that the biuret test can work.
47:56	T1	Just like iodine, remember when we boiled the leaf in Grade 8…
		Yes ma'am
48:00	T1	.. to test for starch, we needed to break down the cell walls in order for the reagent to go inside through the cytoplasm. The same thing occurs here, we have to break down the bonds in order for the solution to go through the substances in order to give us the colour change.
48:45	T1	So, ladies, we also have another indicator, this indicator is called Millons. I am not going to touch it, because it is highly poisonous.

	Learner	Ma’am what happens if you touch it.	
49:31	T1	You die. You die.	
	T1	When you have bigger chains, you need to cook your proteins, you need to introduce energy to that chain in order to break it down. The same thing is going to happen.	
50:00	T1	So according to our experiment, the biuret solution is a blue liquid, which is sodium hydroxide and copper sulphate, it will change purple or violet when proteins are present, and to pink in the presence of short chains of polypeptides. The copper atom of the biuret solution reacts with the peptide bonds to cause the colour change. So, the more purple it is, that is a positive test for proteins	Reads discussion from the booklet

Appendix D: Teacher interview

Title: Investigating the opportunities for developing Science Process Skills in learners: A Study of food tests practical work

Main question:

How does practical work in food tests provide the opportunities to develop science process skills in Life Sciences?

Sub-questions:

1. Which science process skills can be developed through food test investigations?
2. How were the food tests investigations carried out in this study?
3. Which science process skills (if any) were assessed in the practical assessment task?

Interview schedule
Topic of lesson: Organic Compounds – Food test investigations
What the objectives of the practical lesson? Carry out food test investigations
Planning
Researcher: Did you plan to develop science process skills during food test investigations?
Teacher: No.
Researcher: Why?
Teacher: Because there is no time for that. The point of the food test investigations is to show the learners colour changes when different reagents are used for food tests. For example, they must know that iodine is used to test for starch. They must know that the positive test for starch is blue-black. Same applies to lipids, glucose and proteins. But if you think about it, while they are busy with food test investigations, they get to use science process skills, one way or another.
Science process skills
Researcher: Which science process skills will be developed during the food test investigations?

Teacher: Because of time I will show the students how to do the experiments. They will have to watch what I do. Researcher: Will you develop these skills when you have the opportunity? Teacher: Not really, anyway we introduce science method skills in the first term then depending on the experiment we're doing some skills will be used. Also, the focus is on the theory than the skills. Researcher: What are your views about the role of science process skills on concept learning? Teacher: I think they are somewhat important but because of time, and too much content to through it is difficult to develop each and every science process skill. In an ideal world students would have allocated lessons just for scientific skills. Researcher: What are the challenges of developing science process skills in learners? Teacher: To be quite honest, there is really no time at all to develop science skills one by one. On top of that, there is a lot of content to cover so at the end we just rush to finish. Researcher: What are your views about the importance of developing science process skills on science education? Teacher: I do not think they are more important than the understanding of the concepts that we teach in the classroom. Only then can we link skills and practical work. Researcher: In what way does practical work provide the opportunities to develop science process skills? Teacher: I guess this is where they will get a chance to follow the scientific method, they will get to hypothesise, following the instructions by reading the method, they will use the different apparatus, measure, observe and record what they see. Researcher: Do you assess learners' acquisition of science process skills? Teacher: We have a practical assessment task at the end of the term, which is more practical based.

Please tick where applicable:

How often do you **employ science process skills** during instruction?

Basic Process Skills	**Never**	**1-2 a term**	**1-2 a month**	**1-2 times a week**	**Always**
Observing					✓
Measuring					✓
Inferring	✓				
Classifying					✓
Predicting					✓

Communicating					√
Controlling variables					√
Hypothesising	√				
Experimentation					√
Data interpreting					√

Appendix E: Practical Assessment Task sample

LIFE SCIENCES

[redacted]

Term 3 PAT 2024

ANSWER BOOKLET COVER PAGE

63 %

GRADE 10

Name:	[redacted]			Date: 30 August 2024	
Life Science Educator:	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Life Science class:	10E	10D	10C	10A	10T

			Possible Mark	Learner's Mark
Question	1.1.	Microscopy	10	7
	2.1.	Food tests	10	8
	3.1.	Magnification	10	5
Question	4.1.	Scientific Investigation	10	5
		Grand Total:	40	25

Marked/Checked

30 AUG 2024

[redacted]

MARKS: 40

TIME: 40 min

Examiners: [redacted]

This question paper consists of 6 pages

INSTRUCTIONS AND INFORMATION

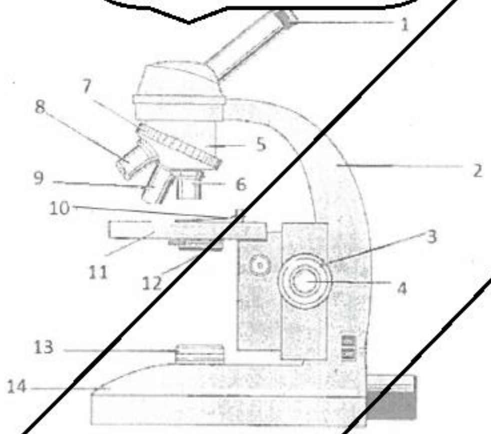
1. Read the following instructions carefully before answering the questions.
2. Answer ALL the questions.
3. Write **ALL** the answers on the question paper in the **SPACE provided**.
4. Present your answers according to the instructions of each question.
5. ALL drawings should be done in pencil and labelled in blue or black ink.
6. **Draw** diagrams or flow charts only when asked to do so.
7. The diagrams in this question paper are NOT necessarily drawn to scale
8. Do NOT use graph paper.
9. You may use a non-programmable calculator, protractor, and a compass if needed.
10. Write neatly and legibly.

GOOD LUCK!!!

Question 1:

Study the image below an

NOT RELEVANT TO THE STUDY



1.1 Provide the correct **labels** for parts **2, 7, 10,** and **14**, respectively.

2: Arm

7: Diaphragm

10: Stage clips

14: Base

(4)

7

1.2 Explain the **function** of parts **1, 6, 11** and **13**, respectively.

1: To observe a specimen through a lens.

6: To view or observe a specimen from futher away or at a low lens.

11: To place the microscope slide.

13: To be able to see the specimen with light.

(4)

1.3 Give **ONE example** of *another type of microscope* that can be used and **how** it *differs* from the microscope shown in the picture above.

~~The electron microscope uses electricity waves in order to see~~

The ~~SEM &~~ TEM uses the microscope to view the specimen in a two-dimensional or three-dimensional manner.

(2)

[10]

Question 2:

During an investigation a grade 10 learner conducted a test on five different food types using Benedict's solution, Iodine solution and Millon's reagent as indicators.

Positive tests for the indicators used are as follows:

- Benedict's solution changes to orange-red
- Iodine solution changes to blue-black
- Millon's reagent turns to brick-red

The results of the investigation are illustrated in the table below.
Study the table below and answer the questions that follow.

Food Type	Food colour observed for each food test		
	Benedict's Test	**Iodine Test**	**Millon's Test**
A	Blue	Blue-Black	Clear
B	Orange-Red	Brown	Brick-Red
C	Orange-Red	Brown	Clear
D	Blue	Blue-Black	Brick-Red
E	Orange-Red	Blue-Black	Brick-Red

2.1 Which food type (**A, B, C, D** or **E**) contains:

Classification skills

(a) Starch only? ~~A, D, E~~ A (1)
(b) Glucose and protein only? ~~B~~, E (2)
(c) Starch, glucose and protein? ~~B~~ E (2)

8

2.2 What other **test/reagents** can be used instead of Millon's reagent?

Experimenting skill

Buiret Test. (2)

2.3 Why is a **water bath** needed for the Bendict's Test?

Experimenting skill

A water bath is needed in order to observe if there is any glucose present via change of colour.

(1)

2.4 Explain ONE **test** for *lipids*.

Communicating skill

Using a filter paper with oil and peanuts to observe the fatty stains that will occur if it is a lipid.

(2)

[10]

Question 3

Study the micrographs below and answer the questions that follow.

3.1 Zanele was given homework to draw the cell using the micrograph on the **left**. The **actual size** of the cell was **2500 µm** and the **drawing size** was **7 cm**. Calculate the **magnification** of the *drawing* she did for homework. Show all working out and round off the answer to the nearest WHOLE number.

$M = \frac{I}{A}$ $7cm \times 10000 = 70\ 000 µm$

$M = \cancel{7cm}\ \frac{70\ 000 µm}{25\ 00 µm}$

$M = 28 µm$

5

(3)

3.2 Determine the **actual/true size** of the chloroplast in the micrograph on the **right**? Show all working out.

Actual size = $\frac{\text{length of object}}{\text{length of scale bar}}$ × ~~as~~ of the scale bar

$= \frac{\cancel{9,7cm}\ 97\ 000 µm}{9,7cm} \times 1 µm$ $9,7cm \times 10000 = 97000 µm$

$= 10\ 000 \times 1 µm$

$= 10\ 000 µm$

(5)

3.3 Calculate the **magnification power** of a microscope if you use the *medium power objective* and the **10X eyepiece.**

~~$M = \frac{I}{A}$~~ $M = 10 \times 10$

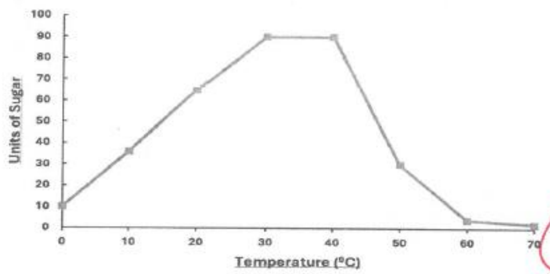
$= 100 µm$

(2)

[10]

Question 4

Amylase is an enzyme that hydrolyses (breaks down) starch into sugars in humans.
Chloe conducted an investigation where a solution of amylase was mixed with a starch suspension.
The solution was kept in a water bath, whereby the temperature was increased every 15 minutes for an hour.
The results of the above investigation were recorded and presented in the diagram below.
Study the table below and answer the questions that follow



5

4.1 Provide a suitable **heading** for the diagram above. ~~Line graph of amylase breaking down~~ ~~and temperature increasing due to a~~ ~~decrease the temperature every 15 mins~~ Line graph showing the relationship between temperature and sugar production of amylase. (1)

Communicating skill

4.2 In this investigation, **identify** the:

(a) Independent variable: Temperature (1)

(b) Dependent variable: Units of ~~sg~~ sugar (1)

(c) Controlled variable: Amylase (1)

Controlling variables skill

4.3 According the graph above, how would Chloe know if the investigation worked?

The temperature increases and so does the units of sugar. This shows that the amylase breaks down starch i

the temperature increased as did the units

(2)

Inferring skill

4.4 State TWO ways by which Chloe could improve the **reliability** of the investigation.

By using two different tubes in a water bath with one that has less starch suspension.

Experimenting skill

4.5 According to the graph, what is the **relationship** between *temperature* and *sugar production of amylase*?

As the temperature increases, s

When the units of sugar decrea

Interpreting skill

(2)

[10]

TOTAL:40 MARKS

Appendix F: Information sheet for the participants of the study

Application for permission: Participation in research

Dear educator

I am a Master's student at the University of Witwatersrand, and I hereby kindly request your permission to conduct research at Beaulieu College in order to research the following topic.

Title of the study:

Investigating the opportunities for developing science process skills in learners: A study of food tests practical work

Background to the study:

This study investigates the effectiveness of one of the features that distinguishes science from most other subjects is the fact that it incorporates practical work, or tasks in which learners manipulate and observe real things and materials. It is argued that practical work incorporates a comprehensive array of activities that may have aims and objectives that are widely different. This argument then gives rise to the proposed study's question, which seeks to understand the effectiveness of science practical lessons in developing Grade 10 learners' scientific process skills. This is because many science educators are of the belief that learner practical work results in better learning. Their reasons being that everyone is able to better understand and remember things if they have done them themselves.

Research procedures:

The voluntary participation of the school in this study will involve an individual interview of 60 minutes with a Life Sciences Grade 10 teacher. The interviews will be arranged at a time which will not disrupt the normal functioning of the school, and which will be convenient for the educator. The interview will be audio recorded. Furthermore, the research entails a class observation of one Life Sciences practical lesson (of approximately 30 minutes) presented by each educator. These lessons will be audio-visually recorded. Lastly, I plan to do an analysis of documents related to teacher's preparation, such as class time tables, Life Sciences lesson plans, worksheets and a sample of learners written work.

Risks, confidentiality and rights of participants:

Information that will be disclosed during interviews is not foreseen to be of a sensitive nature. Apart from the time which class observations, document analysis and an interview may take, participation should not involve any disadvantages or risks to the school and participants.

Although the identities of the participants are known to me, all information will be treated as strictly confidential and participants' identities will not be disclosed in any of the research outputs. Participants are free to withdraw from the study at any time with no consequences whatsoever. Only the supervisor and I will have access to the data collected. Data will be stored safely at the 27 St Andrews Rd, Parktown at the University of Witwatersrand for 5 years, during which time it may be reused for further research purposes.

Benefits of participation in the study

The study will provide more insight into the value of practical work in developing science process skills. The outcomes of this study will be made available to any interested participants, including the office of the principal and the circuit manager.

I hope that you will favourably consider this request for participation in this research.

Yours sincerely,

____

Nonjabulo Portia Nadia Nkabinde (M.Ed student)

E-mail: 549268@students.wits.ac.za

Supervisor: Prof. E. Nyamupangedengu:

e-mail: Eunice.nyamapangedengu@wits.ac.za

Appendix G: Consent form for the participants of the study

If you are willing to participate in this study, please sign this letter as a declaration of your consent. Please complete and return the section below.

I, ____, hereby give my permission to be interviewed and observed as described above. I also give consent that the researcher may study documents related to my teaching, such as lesson plans and learners‟ workbooks. I have been made aware of the following:

- The interview will be audio-recorded;
- The lesson I present will be video-recorded;
- I will be provided with a transcript of the interview to verify my views;
- All information will be treated confidentially;
- My identity will not be revealed in any of the research outputs;
- I may withdraw at any stage of the research process with no ill-consequence;
- No one but the study supervisor and the researcher will have access to the data;
- The data will be stored safely at the University of Witwatersrand for a period of 5 years, during which time it may be reused for further research purposes.

Name of participant: ____________________________

Signature of participant ____________________________

Date: ____________________________

M.Ed student: ____________________________

Signature of student: ____________________________

Supervisor: ____________________________

Signature of supervisor: ____________________________

Date: ____________________________

Please complete and return this page:

I,………………………………………………………………….. give consent to participate the Life Sciences practical lessons described above.

I furthermore give consent to be video recorded during the observations.

I have been made aware of the following:

 My identity will be kept confidential.

 No one but the supervisor and the researcher will have access to the recordings.

 The video-recordings will be stored for 5 years at the University of Witwatersrand, during which time it may be reused for further research purposes.

 I may discontinue with participation at any time with no negative consequences.

Signature: _________________________ Date: ___________________________

Appendix H: Ethics letter

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

WSoE Wits School of Education

SCHOOL OF EDUCATION ETHICS COMMITTEE

CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: 2023ECE027M**
PROJECT TITLE	Investigating the effectiveness of food test practical's in developing Grade 10 learners' scientific process skills
INVESTIGATOR	Nonjabulo Portia Nadia Nkabinde
SCHOOL/DEPARTMENT OF INVESTIGATOR	WSoE
DATE CONSIDERED	12 June 2023
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	Minimal Risk
EXPIRY DATE	Date of submission of the Research Report
ISSUE DATE OF CERTIFICATE	18 August 2023
CHAIRPERSON	Dr. Batseba Mofolo-Mbokane

cc: Prof. Eunice Nyamupangedengu

Appendix I: GDE Ethics letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**12 July 2023**
Validity of Research Approval:	**08 February 2023– 30 September 2023** **2023/211**
Name of Researcher:	**Nkabinde NPN**
Address of Researcher:	**100 8th Avenue**
	Bez-Valley
Telephone Number:	**083 727 3472**
Email address:	**549268@stuedents.wits.ac.za**
Research Topic:	**Investigating the effectiveness of food test practicals developing Grade 10 learners' scientific process skills**
Name of University:	**Wits**
Type of qualification	**Masters**
Number and type of schools:	**2 Secondary Schools**
District/s/HO	**Johannesburg East, Johannesburg Central**

Re: Approval in Respect of Request to Conduct Research

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

12/07/2023

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

1

Making education a societal priority

1. *The letter would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of the relaxation of COVID 19 regulations researchers can collect data online, telephonically, physically access schools, or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate.***
4. ***The Researchers are advised to wear a mask at all times, Social distance at all times, Provide a vaccination certificate or negative COVID-19 test, not older than 72 hours, and Sanitise frequently.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s has been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter/document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs, and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort to obtain the goodwill and cooperation of all the GDE officials, principals, and chairpersons of the SGBs, teachers, and learners involved. Persons who offer their cooperation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
8. *Research may only be conducted after school hours so that the normal school program is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
9. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her research resources, such as stationery, photocopies, transport, faxes, and telephones, and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers, and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
14. *On completion of the study, the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings, and recommendations of his/her research to both GDE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a summary of the purpose, findings, and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Dr. Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 12/07/2023