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The Effectiveness of Kitchen Chemistry in Developing Science Process Skills in High School Physical Sciences

By

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Declaration

I, Zimele Nonkanyiso Mkhaliphi declare that:

i. The research report entitled, "**The Effectiveness of kitchen chemistry in Developing Science Process Skills in High School Physical Sciences**", except where specified, is my original work.

ii. This thesis has not been submitted at any other university for any degree or examination purposes.

iii. This thesis does not contain another person's writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then;

a) Their words have been re-written, but the general information attributed to them has been referenced;

b) Where their exact words have been used, their writing has been placed inside quotation marks and referenced.

iv. The research described in this thesis was carried out in the School of Education, University of KwaZulu-Natal from February 2020 to November 2022 under the supervision of Dr. T Chirikure

v. Ethical clearance No. HSSREC/00003182/2021 was granted prior to undertaking the research.

Signed…[redacted]**……………………** **Date:** 21 March 2022

Supervisor: [redacted] **Date: 22 March 2023**

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Dedication

This document is dedicated to my late brother, Lemphile Mathenjwa, who believed and motivated me to always strive regardless of any challenges. Continue to rest, Ndabezitha. "*Ngilimele ngawe.*

List of abbreviations

CAPS	Curriculum and Assessment Policy Statement
NSC	National Senior Certificate
SPS	Science Process Skills
KC	Kitchen Chemistry
COVID -19	Corona Virus Disease (2019)
SPSS	Statistical Package for the Social Sciences
FET	Further Education and Training
SA	South Africa

Abstract

The purpose of the study was to explore the effectiveness of kitchen chemistry (KC) in developing science process skills (SPS) in high school Physical Sciences. KC refers to using the available tools, materials and household chemicals in performing practical work at home, that is, in the kitchen to provide familiar environments in which learners can participate in practical work without being bound to curriculum time. This study was stimulated by the persisting decline in performance in Physical Sciences in examinations requiring SPS competency. To answer the research questions, a mixed methods research was conducted. Thirty Physical Sciences Grade 12 learners of a rural secondary school in UMkhanyakude District were purposively sampled. Data were generated through pre-tests, post-tests, semi-structured questionnaires and analysis of the documents. Quantitative data were analysed using SPSS. Qualitative data were analysed to isolate and understand salient themes comprehensively. KC was understood as a strategy where kitchen tools and materials are used in learning. It emerged that there was a significant statistical difference in performance after engaging in KC. The learners reported the KC activities as fun and meaningful ways in which learning and understanding of science concepts could occur. Besides, KC activities were effective in stimulating the development of SPS and encouraging knowledge construction. Therefore, it is recommended that Physical Sciences teachers integrate suitable KC activities into their science lessons teaching and planning. The researcher recommends that curriculum developers include the use of KC as one of the suggested alternatives to schools where laboratory resources are limited.

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Chapter 1

Introduction

1.1 Introduction

This study explored the effectiveness of kitchen chemistry (KC) in developing science process skills in Grade 12 Physical Sciences learners. A mixed methods approach was used to study the phenomenon. This chapter articulates the research problem that gave genesis to the research, purpose of the study, research questions, and an overview of the rest of the chapters.

1.2 Statement of the Problem

The importance of practical work in science education is clearly articulated in the South African curriculum. It is stated in the Physical Sciences Curriculum and Assessment Policy Statement (CAPS) that learners must develop competence in Science Process Skills (SPS) (Department Of Basic Education, 2011b). However, various studies conducted locally and internationally have established that practical work in schools is curtailed by a lack of resources and the unavailability of laboratories in high schools offering Physical Sciences, and the schools that have laboratories do not utilise them adequately to develop Science Process Skills (Kibirige & Hodi, 2013; Legotlo et al., 2002; Makgato, 2007; Mji & Makgato, 2006; Selvaratnam, 2011). According to Rogan and Grayson (2003), there have been many initiatives to address inequalities of resources in schools. Nevertheless, learners continue to show a lack of competence in Science Process Skills in matric examinations due to limited opportunities to do practical work (Department of Basic Education, 2019).

COVID-19 created unmatched interruptions to both our education systems and globally. These unprecedented disturbances required changes to the delivery of education. Social distancing and health considerations have made it difficult to conduct practical work in schools where limited resources result in group work and sharing of equipment are the only options. Kitchen Chemistry (KC) is one of the strategies that can be used as an alternative to lab-based experiments. While this strategy has been implemented in other educational settings, debatably, it has not been optimised in South Africa.

Learners' lack in SPS contributes to the declining number of learners enrolling for science courses at the university level, leading to the critical skills shortage in science related professions in the country (Banerjee, 2016; Wolmarans et al., 2010). Incompetence in SPS, especially in high school graduates from disadvantaged schools, is also considered one of many reasons causing an increased dropout rate for first year university learners, resulting in a negative impact on throughput rates for African learners in tertiary education (Department of Higher Education, 2019).

Rogan and Grayson (2003) argued that developing countries must prioritise improving science education to encourage lasting economic development. Science is taken as one of the tools that are vital for the nation and its individuals to succeed economically, as stated by (Mbugua et al., 2012) and become technologically competitive (Du Toit, 2010).

Chemistry is a challenging, abstract and real-life subject that requires it to be taught in a manner that will motivate, build interest and make sense to learners by relating to their practical experiences and environments. Millar (2004) claimed that effective science learning takes place when learners are engaged in the manipulation and observation of real objects in their real-life context. Research affirms that learning occurs when learners are active and participate in the process of acquiring knowledge (Millar, 2004). It creates opportunities for schools and addresses the challenges of resources, timetabling issues and costs of running school laboratories as KC allows learners to do experiments in their time and utilise household materials. This will encourage teachers who focus on content coverage while neglecting practical work to create opportunities for developing SPS (Ping et al., 2019).

The background of the study was founded on the previous findings and outcomes of previous studies conducted on KC uses and its significant impact on the teaching and learning of science. It is also grounded in my practice as a Physical Sciences teacher in an under-resourced school without laboratories to perform and engage learners in practical work.

1.3 The Purpose of the Study

This study explores the effectiveness of KC in developing science process skills in grade 12 Physical Sciences learners in Ingwavuma Circuit in UMkhanyakude. An explanatory sequential mixed methods design was used. The quantitative data was explained in-depth with qualitative data. Pre-test and post-test data were collected from learners to assess if there was a statistically significant difference between the two means of pre-tests and post-tests data. Qualitative questionnaires provided data to explain the effectiveness of KC.

1.4 Significance of the Study

The study may be useful to teachers of under-resourced schools who have insufficient resources for learning and teaching science. It will be helpful to subject advisors, subject specialists and curriculum specialists who are constantly engaged in understanding learning, educational procedures and processes to make informed professional decisions. The curriculum developers may find the study essential and include KC as a strategy to be utilised by teachers and learners where laboratory-based practical work is impossible or insufficient. The findings of the study are also beneficial to me as a researcher and teacher who wants to improve instructional strategies.

1.5 Research Objectives

- To determine if there is a statistically significant difference in the performance of the learners prior and after doing KC.
- To determine the level of effectiveness of KC in developing science process skills.
- To explain the level of effectiveness of KC in developing science process skills in learners.

1.6 Research Questions

1. Is there a statistically significant difference in the performance of the learners before and after doing KC?
2. How effective is KC in developing science process skills in learners?
3. What explains the level of effectiveness of KC developing SPS in learners?

1.7 Research methodology and research design

In this study, a pragmatic paradigm was used. This paradigm is based on the notion that mixed methods designs want to explore concepts from more than one philosophical worldview and design viewpoint, thereby creating a more "practical" view concerning the overall conclusions. The mixed methods approach was followed in this study because of the view that combined quantitative and qualitative data boosts the validity of the research findings (Creswell & Creswell, 2018). This enabled the researcher to make a better understanding of the research topic in order to provide detailed views and clear solutions to the research questions and make informed recommendations (Tashakkori & Creswell, 2007). The rationale for this methodology is to produce credible findings and also extract sound ideas of the subjects of interest by the researcher. To collect data, the researcher selected three data collection procedures namely, pre-tests and post-tests, semi-structured questionnaire and document analysis.

1.8 Findings

The results obtained from this study emerged from the in-depth analysis of the qualitative data generated from the semi-structured questionnaire and document analysis of both the pre-tests and post-tests. The findings also emerged from the quantitative data generated by the pre-test and post-tests.

1.9 Structure of the thesis

The thesis is planned and presented sequentially in six chapters that define different phases of the study.

Chapter 1 begins with a comprehensive background of the study. This chapter outlines the purpose and significance of this study. The research aims and objectives are clearly articulated in this chapter. Chapter 1 also highlights the research questions, as well as the findings and the structure of the thesis.

In Chapter 2, there is an evaluation and a review of relevant literature that informed the study. The purpose of practical work, development of SPS and Kitchen Chemistry literature is reviewed.

Chapter 3 focuses on the constructivist theory and the model by Millar (2009), which is the theoretical framework of this study.

In Chapter 4, the focus is on the research design and research methodology that was carried out in this study to answer the research questions. The chapter also outlines the pragmatic paradigm and mixed methods design in which the study is framed. A discussion of the data collection instruments adopted together with the analysis procedure used to analyse the collected data is presented in Chapter 4. The ethics that were subscribed to throughout the study are discussed in the chapter.

Chapter 5 focuses on data presentation and data analysis of the results. Qualitative and quantitative data are presented. The findings of this study are also discussed in Chapter 5.

In Chapter 6, there is a summary of the conclusion and implications of the study. The following chapter covers a detailed literature review associated with this study.

Chapter 2

Literature Review

2.1 Introduction

The chapter begins with a general science outline and varied classifications of practical work. Furthermore, the overall purpose of practical work and its significance in the process of learning and teaching science as drawn from numerous research studies was discussed. The science process skills and categories are also discussed. The literature was also used to describe the theoretical framework that was used in making sense of the data that were generated in this study.

2.2 Science and Practical Work

Science is defined as the study of both chemical and physical phenomena (Department Of Basic Education, 2011a). It is a method of discovering explanations and linking ideas. Chemistry is a subdivision of science that explores the relations between matter and energy. The practical nature of science empowers learners to develop SPS that can be utilised in problem solving. Millar et al. (2002) argue that the objective of teaching science is to stimulate the development of an understanding of the natural world. This view is shared by Millar (2004) who asserted that these objectives include supporting learners in building an understanding of the knowledge of science as applicable to their needs, interests and capacities. Science aims to improve learners' understanding of processes to gain knowledge that would stimulate scientific skills development.

Moeed and Anderson (2018) posit that science education is an essential focus in the science curriculum of most developing and developed countries, as it induces significant clarifications about the material world. In addition, Physical sciences is considered as the foundation of technological development (Olufunke, 2012). This view is outlined in the CAPS for Physical

Sciences which encourages skills and knowledge in enquiry and problem solving. Learners must develop competence in SPS which must include the capability to accurately reason and engage in a wide variety of forms of cognitive reasoning skills whilst using SPS. Practical activities must be incorporated with theory to reinforce the theoretical concepts taught (Department of Basic Education, 2011a).

Practical work in the form of practical experiments and investigations forms a fundamental section of the formal programme of assessment in CAPS (Department of BasicEducation, 2011a). Assessment in Grade 12 Physical Sciences emphasises and prescribes that learners must obtain 25% of their examination mark from practical work (Department of Basic Education, 2011a). This suggests that the practical component of science is an essential component of the science curriculum. Hattingh et al. (2007) found out that teachers neglect practical work related activities. These findings coincide with Muwanga-Zake (2001) in the Eastern Cape province where teachers ignore practical activities, leading to poor performance in SPS. Consequently, subject enrolment in Physical Sciences has declined (Department Of Basic Education, 2018).

In this study, Science was viewed as the study of both chemical and physical phenomena and therefore, will define any form of practical work, experiments and investigations as identified by (Woolnough & Allsop, 1985) as a pedagogical tool where learners participate cognitively in engaging with phenomena to develop SPS.

2.3 The Purpose of Practical Work

Chemistry practical experiments, laboratory activities and investigations are instrumental to learners' achievements of essential classifications and science process skills throughout their high school phase of education. Practical work is a significant and unique feature of the learning and teaching of science (Millar & Abrahams, 2009). Chemistry is a practical science that requires practical experiments (Dietmar & Lawton, 2010). In every science lesson, teachers try to expand learners' knowledge of the natural world through practical work. That is why it is always anticipated by learners during science learning (Wellington & Ireson, 2012). This view is shared by Moeed and Anderson (2018), who further suggest that the practical component of science and its activities are a dominant feature in the process of teaching science. Practical work remains a fundamental constituent of science education despite the ongoing arguments and discussions around its input and value in science classrooms.

Studies conducted by Skamp (2011) revealed that teaching through engaging learners in practical activities creates a vibrant learning environment in which an improvement in learner performance could be achieved. However, according to Toplis (2011) , the literature suggests that there is an ongoing argument on the significance of practical investigations and activities on learning. Others have argued that practical work is an expensive pursuit of schooling. However, a science practical activities based lesson can excite learners by providing first-hand knowledge and supporting theoretical teaching (Wellington & Ireson, 2012). The focus of practical work is to support learners to advance and build knowledge of the world Millar (2009) and stimulate the generation of new knowledge (Moeed & Anderson, 2018). Practical work can also be viewed as supplementary to previously taught scientific concepts and the next observation (Millar et al., 2002).

However, the significance of a practical task depends on its ability to advance learners' scientific knowledge, their ability to identify objects and phenomena and how they learn concepts, including theory, relations and specifics (Millar, 2002). When practical work is utilised efficiently, it can influence learners' views, and their learning and stimulate and engage learners both physically and mentally (Woodley, 2009). Kibirige et al. (2014) further confirm that practical work is an effective approach to improving performance. It is believed that learners are likely to grasp and understand things they have engaged with, both physically and cognitively, leading to better learning (Millar & Abrahams, 2009).

Furthermore, it then appears challenging to teach or rather mention or argue about science education without directly talking about practical teaching methods of science. Practical work allows learners to experience science by engaging in scientific research processes, thereby achieving meaningful learning (Hofstein & Lunetta, 2004). Learners need to realise that practical experiments and theory are interconnected. Kibirige and Hodi (2013) suggested that for learners to understand scientific theories and how to apply them, they must be taught using practical activities. According to Abrahams and Millar (2008), it is a shared view of most teachers that practical work is fundamental to the efficiency of teaching science. Some refer to the old axiom by Confucius, that is: "I hear and I forget, I see, and I remember, I do and I understand."

Practical work allows learners to perform experiments and act like scientists in creating enthusiastic learners who are always excited and engaged in learning science lessons (Toplis, 2011). Regardless of any given definition of practical work or the role it plays in schools, it can be described as a central part of science learning and teaching. Hence, it must be done effectively. Studies by Hartley (2014) suggest that the main function of practicals in the curriculum in South Africa (SA) is undervalued, particularly by teachers who come from disadvantaged schools. This manifests itself during workshops and subject content meetings for science teachers. They are often characterised by complaints of enormous administration and paperwork. They view the engagement of learners in practical work as an exercise that is time consuming and it is the time that they openly lack. The purpose of this study was to substantiate or invalidate most of these in looking at alternatives to school-confined practical activities in agreement with Millar (2010) that investing in good quality practical work activities will have a long-term effect on both learning and teaching of science.

Exposing learners to testing theories and engaging in practical work provides opportunities for them to acquire SPS and understand science concepts. It can be argued that practical work requires good planning and a dedicated environment for effective execution to enrich learning and the use of knowledge (Mji & Makgato, 2006). However, the literature reveals that only very few schools have the privilege of using a laboratory to support learning, therefore, the benefits of practical work are not realised in schools that lack resources (Mji & Makgato, 2006).

Literature has revealed considerably similar purposes of practical work and will be summarised in Table 2.1 to create a clear picture:

Table 2.1

Summary of the Purposes of Practical Work Found in Literature

Purposes	**References**
• Development of investigation or exploratory skills. • Development of practical and functional ideas of science. • Build understanding and explanations of what constitutes science, that is, its nature.	Moeed and Anderson (2018)
• To supplement learning activities of science so as to improve learning. • Training learners on the use of laboratory skills. • Development of attitudes towards science. • To serve as motivation by stimulating interest and enjoyment.	(Abrahams, 2011)

• Providing chemistry learning skills. • Practical skills, such as tools and chemicals handling, measuring and observation. • Science and General Abilities, such as group work, communication (written and orally), time management and solving problems.	Reid and Shah (2007) cited in (Dietmar and Lawton (2010, p. 88)
• Handling. • Observing and correctly keeping records of data. • Process and interpret data. • Capability to design experimentations.	Johnstone and Al-Shualli (2001) cited in (Lyall & Patti, 2010)

Practical work can be defined in various ways and so does the way it impacts learners in their learning process. In literature, it is commonly deduced that for learners to understand any science concept, it must be considered that it just cannot be purely transferred from the teacher to the learners. However, it requires the active participation of learners to understand new information.

2.4 Science Process Skills (SPS)

The one most important and persistent goal of science teaching is to ultimately teach learners the ability to reason and enquire. This is a goal to be shared amongst all school subjects. The teaching of science provides unique skills with an emphasis on interpreting and drawing conclusions from data. Teaching SPS for their development amongst learners can be done variously, however, the predominant way to consider is by presenting opportunities that allow for their development. In this view, the national science curriculum has emphasised the importance of learners developing SPS in its CAPS for Physical Science (Department Of Basic

Education, 2011a). SPSs are well-defined as a group of generally exchangeable capabilities relevant to a wide range of science disciplines and reflect the behaviour of science experts (Juhji & Nuangchalerm, 2020). CAPS discusses and identifies all the SPS learners are expected to develop (Department Of Basic Education, 2011a). SPS are the identified skills that are taught as mandatory to the implementation of the science curriculum. Therefore, the learning and teaching of science should be a direct contact experience through learning based on SPS (Juhji & Nuangchalerm, 2020). This view concurs with that of Abrahams and Millar (2008) who suggest that conceptual understanding whilst engaging learners in practical work is vital for the different categories of SPS development.

SPS are categorised into basic and integrated science process skills. According to Rambuda and Fraser (2004), basic SPS applies particularly to basic cognitive functioning, especially in foundation phase grades, and these skills form a background for advanced problem-solving skills and capacities. Rambuda and Fraser (2004) further reiterate that in the South African science education context, SPSs are what determine the outcomes of learning science. A learner will have to master the basic SPS to be successful in dominating the integrated SPS (Turiman et al., 2012). This view is supported by Millar (2002) who elaborates that practical work not only engages learners but it necessitates advanced learning of skills. Basic SPS are skills such as classifying, observing, measuring and predicting. Integrated SPS are process skills for resolving research problems in the form of science investigations (Juhji & Nuangchalerm, 2020). The SPS and their explanations are shown in Table 2.2.

Table 2.2

Summaries of Explanations of Science Process Skills (adopted from Padilla, 1990)

SPS	Explanation
Classifying	Placing objects or events in a particular order, group or category based on their properties.
Observing	Using the senses of touch, smell, seeing and feeling together or partially to collect information about an event or a series of events and objects. Example: describing the temperature changes of ice melting.
Inferring	Using previously known information or using theory to guess an outcome of an occurrence.
Measuring	Describing an object using its dimensions.
Communicating	Describing an object or an action of an object, incidents and occurrences using words, symbols or graphs.
Classifying	Categorising objects and incidents in a particular order based on certain criteria.
Predicting	Using evidence or a pattern in evidence to state an outcome.

Despite the strong emphasis on the improvement of developing the basic and integrated SPS, literature has also shown that due to the traditional methods, scope coverage and value placed on conceptual understanding over skills development, learners have misconceptions about SPS because of a lack or inadequate opportunities to actively participate in science tools to assist the development of SPS (Rambuda & Fraser, 2004). In the same vein of the emphasis on the development and learning of SPS in science, this study sought to find out what opportunities exist to enact KC as a practical learning tool to enhance the attainment of SPS and the extent of the effectiveness in developing SPS.

Arguably, the development of SPS can be achieved through teaching and learning that involves practical activities. Millar (2004) suggested that engaging learners in practical activities will nurture SPS. Exposing learners to a variety of skills-based instruction to manipulate authentic equipment and materials form the basis for scientific enquiry. Research reveals that for learners to excel, be competitive and overcome the challenges of modern technology, they must be well-equipped with scientific skills (Du Toit, 2010).

SPS help learners in understanding phenomena, answering questions, developing theories and discovering information. They are essential in developing ideas and increasing academic achievement in science learning. CAPS for Physical Sciences highlights the skills relevant for learners to study Physical Sciences as "classifying, communicating, measuring, designing an investigation, drawing and evaluating conclusions, formulating models, hypothesising, identifying and controlling variables, inferring, observing and comparing, interpreting, predicting, problem-solving and reflective skills" (Department of Basic Education, 2011a, p. 8). Although CAPS emphasises the nurturing of these skills at the early stages of learning, learners consistently demonstrate a lack of competence in SPS.

SPSs serve an important role in helping learners understand the scientific approach. According to Turiman et al. (2012), SPS forms the background necessary for problem solving in support of knowledge enquiry and scientific literacy. It is evident that SPSs have an important role to play in the learning of Physical Sciences and these are summarised in Table 2.3 below:

Table 2.3

Science Process Skills and Their Significance

Basic science process kills	Type	Significance/Importance
	Observation Communication Classification Measurement Inference prediction	Used to investigate and explore. Forms foundations for the knowledge of science and technology (Turiman et al., 2012). Prepares learners for the learning of integrated skills. Promotes effective learning and understanding of science content.
Integrated science process skills	Interpretation of data Experimenting Control variables Operational definition Hypotheses (Department Of Basic Education, 2011a)	Skills used for solving research problems through scientific experiments (Juhji & Nuangchalerm, 2020).

SPS are categorised into basic and integrated and Table 2.3 describes the significance of their type. The development of SPS in this study is discussed by considering ways in which the home environment can be used to stimulate learning SPS by engaging learners in appropriately designed KC activities. Science process skills may be considered as the building elements of successful science learning.

2.5 Factors Affecting Practical Work in Schools Without Laboratories

Teaching science by exposing learners to practical work has been considered by scholars as what characterises a science teacher (Hofstein & Lunetta, 2004). The fundamental goal of science teaching and learning is for learners to be competent in SPS, in other words, learners must engage in practical work. However, there have been many factors identified in the literature that impede practical activities. Muwanga-Zake (2004) confirmed that a lot of teachers neglect the practical component of science and do not create opportunities for practical activities for learners because of their inability and incompetence to handle practical work equipment and resources. Moreover, according to Mji and Makgato (2006), the scarcity of laboratories in most schools in the country has been identified as contributing to teacher-centred science lessons taught out of a textbook without supplementing it with practical work.

Hence, most rural and under-resourced school learners are required to rely on the memory of experimental activities instead of authentically engaging in practical work. Additionally, (Kibirige et al., 2014; Legotlo et al., 2002) revealed various factors affecting practical work in science, including a lack of experimental resources (they are either insufficient or ineffective), teachers not planning or designing practical activities and the time to reflect on the experience of the experiment is usually insufficient.

Only a very small percentage of public school infrastructure in South Africa offering science has laboratories and only a fewer have laboratories with the tools, reagents and laboratory items needed for practical work. Meanwhile, the Department of Basic Education (2011a) mandates practical work from teaching to assessment.

2.6 Kitchen Chemistry

KC has been identified by Yip et al. (2012) as a learning environment that is life relevant. Although there exist numerous different definitions of KC, however, it is commonly defined as the use of general household chemicals, materials and tools to perform science investigations in a familiar setting such as the kitchen (Dietmar & Last, 2000). Some scholars argue that KC involves practical activities that can be used to improvise for school grade chemicals and tools to do investigations in teacher supervised settings such as in a school classroom, open space or laboratory. It is developed by scholars Yip et al. (2012), as a medium for engaging and supporting learners in designing personalised enquiries. It is based on using kitchen ingredients to do practical activities in school whilst some view it as an after-school platform where learners engage in scientific knowledge development practices within the context of cooking.

This study views KC as using the available tools, materials and household chemicals in performing practical work at home, that is, in the kitchen to provide familiar environments in which learners can participate in practical work without being bound to curriculum time. The kitchen can be assumed to be a general context that can supplement science learning. This allows for flexibility in choosing appropriate spaces, time and convenient environments to design investigations that allow making scientific meaning. It is regarded by Jacobsen (2011) as a prime setting and location for the learning of science at home so that learning finds relevance in learners' lives. According to Royce (2010), the kitchen is regarded as a “wondrous” setting for learners to engage themselves in making learning observations, including the exploration of the basics of science, in particular, chemistry.

Learners often find science to be detached from their ordinary everyday reality. Hence, it is suggested that KC can bridge the gap. Similarly, Dietmar and Lawton (2010) believe that if teachers can apply sufficient creative effort, the educational outcomes achieved in the classroom can be achieved outside the traditional laboratory too (Dietmar & Lawton, 2010). Studies conducted by Reeves and Kimbrough (2004) and Nuora and Välisaari (2019) suggested that KC practical activities enriched learners' appreciation of the significance of everyday chemistry and created passionate and enthusiastic learners. This is because KC involved accustomed resources and measurements done in familiar environments. Obi and Obi (2019) concluded that learners taught using improvised readily available materials performed better than those that were taught without them.

According to Reeves and Kimbrough (2004), teaching and learning using KC experiments has been identified as suitable for any age. It can stimulate interest and relate chemistry to everyday occurrences. In that view, KC may be used as one of the teaching and learning strategies for enhancing and stimulating knowledge. KC uses materials that are obtainable from common hardware stores. It involves fewer hazardous chemicals and techniques to allow learners to explore. Hence, KC has been suggested by Dietmar and Last (2000) as an alternative approach to laboratory-centred experimentations and demonstrations. Nevertheless, a predominant concern about KC investigations is that they lack the accuracy and consistency of traditional experiments and fail to expose learners to the new and technologically inclined tools used in contemporary science laboratories (Lyall & Patti, 2010).

Results of studies such as Casanova et al. (2006) (although not in a schooling setting) suggest that KC is a "unique" method that helps learners value the applicability of everyday chemistry in their day-to-day lives. Given the recent disruptions in education caused by the unanticipated Covid-19, learners engaged in KC showed to have improved in achievement (Schultz et al., 2020).

KC, as noted by Yip et al. (2012),is a hands-on setting. It allows for experiments to be performed safely and inexpensively without the acquisition of expensive commercial laboratory kits (Nguyen & Keuseman, 2020). For learners to learn science, they need to be constantly involved in the enquiry process of knowledge. This was observed in a study where learners engaged in KC had more questions to ask (Obi & Amba, 2014)

It is very important to assist learners to see the relevance of scientific knowledge to their lives and involve them in chemistry, hence, the study seeks to add to the literature and the body of knowledge on KC.

2.7 Summary

In this chapter, the literature related to the lack of practical work in science education was reviewed and the factors affecting practical work in schools in science education. An overview of the science and practical work was outlined. The chapter captures a description of the science process skills and their importance in science education with a strong emphasis on skills development envisaged by CAPS. Studies related to the use of KC to create opportunities for skills development were also reviewed. The next chapter describes the theoretical framework and models which were used to explain and make sense of the data obtained in the study.

Chapter 3

Theoretical Framework

3.1. Introduction

The previous chapter was a review of the literature on the significance of practical work to stimulate the development of science process skills and the use of KC in science education. This chapter describes the theoretical framework that was used to make sense of the data collected. According to Lederman and Lederman (2015), a theoretical framework is a supporting structure of the theory of the research study. It sets and elaborates on the model or the theories that underpin the study. Learning and teaching theories that influence competency in skills play a significant role in providing guidelines to teachers on how best to teach science in a school, hence, the effective learning and teaching of SPS can be done with the application of theories in the learning settings.

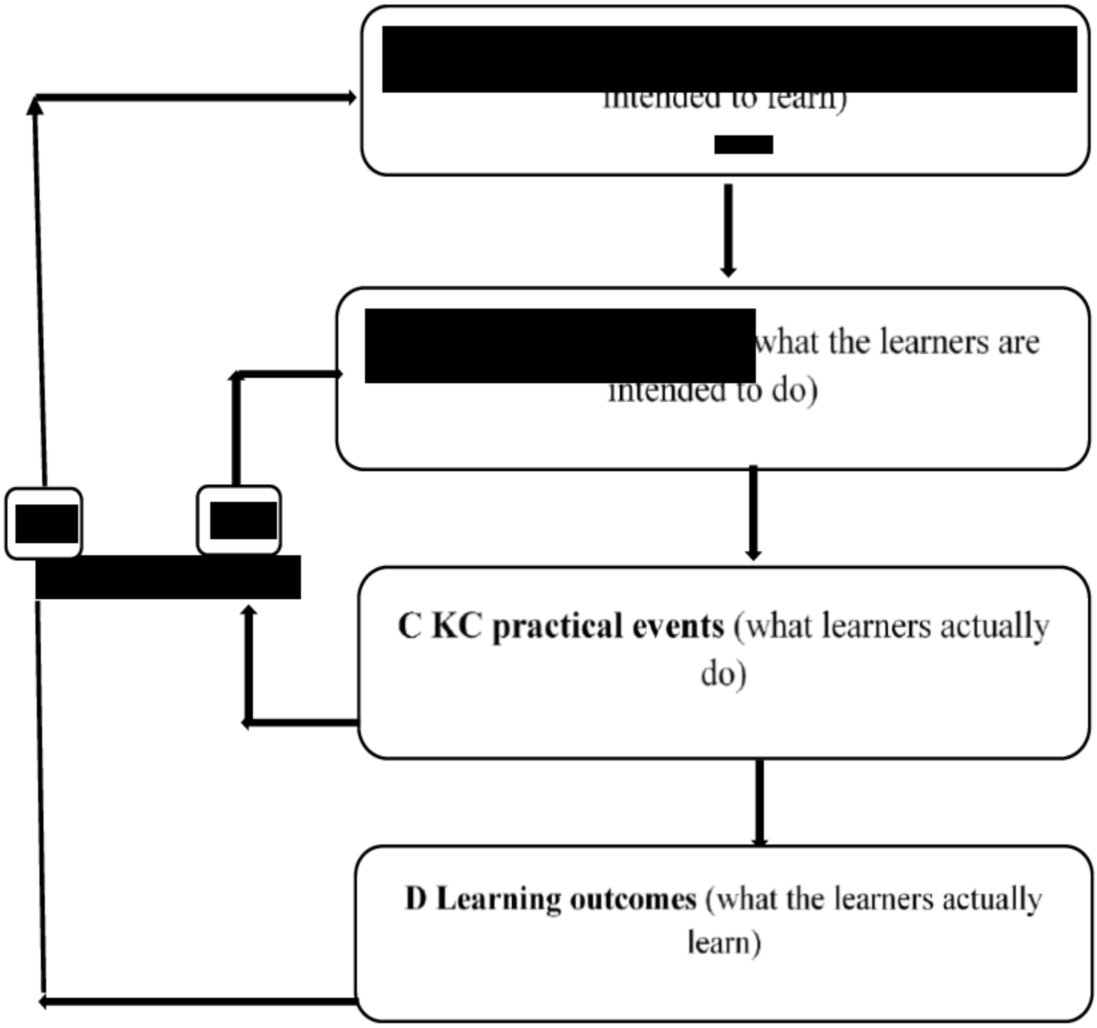
3.2. Framework for Evaluating the Effectiveness of KC Activities

To evaluate the level of effectiveness of a practical activity, the design and the method involved in creating the activity are taken into account. In an attempt to establish the relationship between SPS with practical activities, the model developed by Millar (2009) (Figure 3.1) is adapted to provide a framework for the evaluation of the effectiveness of the KC practical activity in developing SPS. This model considers the effectiveness of a practical task in relation to the learning objectives of the teacher and what learners do or learn from the activity.

Teacher's objectives (Box A): The teacher's objectives consist of the teacher's intentions. What do we want learners to absorb and acquire throughout the activity? The teaching and learning goals of the KC activity are knowledge, learning and competence in SPS. How the KC practical activity is designed influences how learners conduct, analyse and interpret their findings.

Figure 3.1

Model for Evaluating the Effectiveness of KC in Developing SPS (Adapted from Millar (2009)



The Activity Specification (Box B): The learning objectives must be transformed into a clear activity that will avail authentic opportunities to stimulate the development of SPS and what learners must or should do to achieve learning outcomes. When and what must be observed, measured and recorded during the experiment is specified.

The KC Events (Box C): When an experiment is conducted in a classroom, the teacher can observe what the learners do. In this study, the KC practical activities were conducted at home.

The practical activities are influenced by the learner's preceding information on the topic, knowledge of the use of tools and materials and the learners conducting the practical. If the learner's activities match and relate to the teacher's objectives set in Box A, then, Level 1 effectiveness is achieved. If the learners can use the SPS set out in Box A and show confidence and competence in SPS, then, the practical activity will be considered effective. This model was suitable for the study in that the effectiveness of KC events in developing SPS was tested in the practical tasks so that it necessitates for the researcher to conclude on the effectiveness of KC in learning SPS from the performance in the tests. The model used to evaluate the effectiveness of KC in developing SPS is summarised in Figure 1.1.

The Learning Outcomes (Box D): Learning outcomes are defined as descriptions of the exact knowledge, expertise or skills the learner will acquire from a lesson or activity (Biggs & Collis, 2014). If the teacher's objectives set out in box A directly become learning outcomes of Box D through practical activity, then, that practical activity is said to be effective and will be regarded as effectiveness level two (2). The learners can interpret their collected data and answer their investigative questions and the development of SPS.

The purpose of the KC tasks is to assist learners to derive links and connections between the two dominions of knowledge: the domain of observables and objects which require learners to make observations and the domain of ideas and will be summarised in Figure 1.2.

Figure 3.2

Practical Work: Helping Learners to Make Links Between two Domains

Note. This figure was produced by Millar (2009) to show the interlinked functions of practical work in assisting learners to gain knowledge.

In the light of the model of effectiveness set out in Figure 1.2, what learners do with the ideas and concepts will be considered, together with what they do with the tools and objects (Box C) and we need to establish the level that the activity improves learning of concepts and not simply the capability to memorise the observed tasks and events (Box D).

In terms of both domains, the confirmation and a distinct indication of whether the KC activity was effective is set out in Table 3.1.

Table 3.1

Analytical Framework for the Effectiveness of KC: Evidence that would indicate Effectiveness in Each Level, and in Each Domain (Millar, 2009).

A practical activity is:	in the domain of objects and observables (o)	in the domain of ideas (i)
effective at level 1	If the learners can: - Design the activity - Use a thermometer as expected. - Measure accurately. - Make meaningful observations as intended by the KC activity.	During the KC activity, learners think about: - What they are engaged in. - Their observations. - How they use the concepts proposed or implicit in the activity
effective at level 2	Learners can: - Set up the activity. - Use the concepts of the activity to understand the scientific concepts. - Recall their observations.	Learners can: - Make meaningful discussions about the activity using the ideas the KC activity was aiming to develop. - Show understanding of these ideas of the KC activity in different or related concepts.

The model (Figure 3.1) was used to focus to the study on the effectiveness of the KC activities in developing SPS in learners and also designing questions to stimulate learners to reflect on their experiences of doing a KC activity on the topic of factors affecting a rate of reactions.

3.3. Constructivist Theory

A learning theory describes how learners absorb, analyse and retain knowledge during learning. It is based on how learners build up the knowledge to understand the world by testing and reflecting upon their practices. The learning and teaching of science process skills may be described by the constructivist theory. The constructivist theory underpins learning and teaching strategies recommended for science teaching. KC is one of the strategies described in this study, therefore, an explanation of this theory is required to illustrate the background for the learning tasks and activities of the study.

This model is based on the view that for learners to develop intended skills and understand what they learn, they must actively participate in the processes and procedures rather than passively be given information by their teachers (Woolfolk, 2014). These views are shared by Driver et al. (1994) who noted that learners must be allowed to create their meanings through active explorations of ideas and phenomena. Constructivism perceives learning as an active and social process through which learners actively create meaning in their experiences by connecting them to prior knowledge (Driver et al., 1994). It is through this exercise that the learning of skills takes place. This argument is maintained by Tobin (1990) who suggested that practical work encourages learners to use science skills to create meaning and understanding while engaging in the process of creating information about the skills intended by doing science. The KC activities allowed learners to engage themselves in generating knowledge for the understating and learning of science skills.

Constructivist teaching methods provide experiences that facilitate the construction of knowledge (Fosnot, 2013). This is a result of the belief that learners pursue knowledge of the world surrounding them and in which they are constantly engaged (Creswell, 2014). Moreover, the views of constructivists emphasise procreative learning and questioning approaches where the learner is forced to be an active participant. Such approaches stimulate cognitive awareness amongst learners to realise the skills involved in constructing an understanding of the concepts being delivered. A detailed analysis and elaboration of the constructivist approach does not particularly strive to encourage learners to be dynamic intellectuals, however, it also aims to stimulate teamwork amongst learners (Kapanadze & Eilks, 2014).

Constructivism perceives learning as an active and social process through which learners actively create meaning in their experiences by connecting them to prior knowledge (Slavin, 1994). Constructivist views are emphasised by Millar who suggested that science learning at the school level does not involve new or unfamiliar concepts but is grasping what others already know about certain concepts on their own (Millar, 2004). During KC activities, learners are fully responsible for the control of the process of learning skills, knowledge of concepts and understanding of the scientific process. In the process, it becomes significant to allow learning settings that will stimulate them to test hypotheses, design activities and ask questions that are both hands-on and minds-on (Gunstone, 1990). Therefore KC experiences can provide such opportunities for learners to allow them to construct scientific knowledge and gain science process skills.

In addition, science education primarily includes presenting science materials and exposing learners to learning settings that allow them to learn skills, draw conclusions and therefore construct knowledge (Millar & Abrahams, 2009). This view supports the constructivist’s views that learners must actively take part in the formation of their understanding to master skills. Learners possess unique individualised ideas about the world (Sjoberg, 2010). Hence, teachers shape learners' existing information of the world surrounding them and enhance it by designing learning tasks that allow learners to interact and observe true materials, tools and objects (Millar et al., 2002).

Constructivists emphasise using teaching techniques that command learners to be actively involved in learning skills to stimulate understanding. These teaching methods must encourage learners to be cognitively engaged in building personal understanding. Constructivism also aims to encourage learners to be active thinkers and promote communication and collaboration amongst themselves for effective learning (Kapanadze & Eilks, 2014). A constructivist theory provides science teachers with a powerful perspective for taking into account learners' ways of developing a good sense of their experiences of the natural world (Taylor, 1998).

Tobin (1990) founded his review on constructivism views of providing learners with learning practices that promote effective learning in the laboratory that would enable effective learning in the science laboratory. He suggests that "Laboratory activities are a way of allowing learners to learn with understanding and, at the same time, engage in the process of constructing knowledge by doing science" (Tobin, 1990, p. 405).

In light of this theory, the learning of SPS by the learners through active engagement in KC activities will be considered as learning that has occurred as a result of an active learning environment. Learners require concrete materials in engaging with learning concepts. The constructivist theory underpins learning and teaching strategies recommended for science teaching. In this study, it will be used to analyse the learning occurring during active engagement through KC. This learning theory has direct effects on the development of SPS.

3.4. Summary

In this chapter, the theoretical frameworks that underpin the study were outlined. The model by Millar (2009), including constructivism, was described as how it was going to be used to explain the collected data and make sense of the data and findings. The model was used to answer questions two and three on the effectiveness of KC. The succeeding chapter describes the research methodology which was used in the study.

Chapter 4

Research Design and Methodology

4.1 Introduction

The previous chapter was a description of the theoretical frameworks. This chapter describes the research design, the data collection methods and the research instruments that were used to answer the three research questions which are: Is there a significant difference in the performance of the learners before and after doing KC? How effective is KC in developing science process skills in learners? What explains the level of effectiveness of KC in developing SPS in learners? A research design is an approach in an investigation that provides details on processes and events of collecting relevant data for research (Creswell, 2014). The main aim of this methodology was to extract meaningful information from the learners. A pragmatic paradigm and mixed methods research approach were adopted in this study. The researcher discusses the research design that was used to answer the research questions and mainly to explore the effectiveness of KC activities in developing SPS in Physical sciences learners. The sampling methods, data generation instruments and data analysis techniques that were used in this research are described.

4.2 The Research Paradigm

In this study, a pragmatic paradigm was used. This paradigm is based on the notion that mixed methods designs want to explore concepts from more than one philosophical worldview and design viewpoint, thereby creating a more "practical" view with reference to the overall conclusions. According to Creswell and Creswell (2018), pragmatism does not commit to a single system of philosophy and in reality, this then applies to mixed methods research in that researchers extract substantially from both qualitative and quantitative assumptions when they participate in research. Thus, for the mixed methods researcher, pragmatism unlocks and opens doors to multiple methods, diverse worldviews and various assumptions as well as different methods of collecting data and data analysis. To this effect, the objective meanings were obtained from scores on the pre-tests and post-tests that provided the quantitative data. The learner's experiences of KC in place of school practical work provided subjective meanings.

According to Cohen et al. (2018, p. 34), pragmatism is applicable when the research focuses on:

> framing and answering the research question or problem, which is eclectic in its designs, methods of data collection and analysis, driven by fitness for purpose and employing quantitative and qualitative data as relevant, i.e. as long as they 'work' – succeed – in answering the research question or problem, and in which the researcher employs both inductive and deductive reasoning to investigate the multiple, plural views of the problem and the research question.

The combination of qualitative data and quantitative data in a study converges the advantages of depth associated with these research approaches (Teddlie & Tashakkori, 2009). Pragmatism subscribes to the notion that reality is temporary; there can be single or multiple authenticities (Creswell, 2014). Mertens (2015) suggests that there is a single actual world and different personalities of individuals interpret that world differently. The objective reality in this study was obtained from the performance of the learners on the pre-tests before engaging and the post-tests after engaging with the KC activities.

Epistemology is a theory of knowledge and deals with how knowledge is gathered and from which sources (Cohen et al., 2018). According to Cohen et al. (2018), it is an implicit model about how we know what we think we know. Objective meanings were obtained from scores of the pre-tests and post-tests that provided the quantitative data.

- The axiological perspective in this research has to do with the philosophical study of value (Mertens, 2015). During qualitative data collection, the participants' meanings they attached to the KC activity, there were responses to the semi-structured questionnaire, thus there were some interactions with the participants. Any bias in the research could have been on the type of questions the participants were responding to. The axiological perspective in this research has to do with value ethics (Mertens, 2015). During the quantitative phase, the researcher assumed an etic and then an emic position during the qualitative phase.

4.2 Research Approach

The mixed methods research approach was used in this study because of the view that combined qualitative and quantitative data increases the validity of the research results (Creswell & Creswell, 2018) and enabled the researcher to make a better understanding of the research topic in order to provide detailed views and clear solutions to the research questions and make informed recommendations (Tashakkori & Creswell, 2007). The rationale for this approach is to produce credible findings and also extract sound ideas of the subjects of interest by the researcher. This approach is broadly defined as:

> "research in which the investigator collects and analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches and methods in a single study or a program of enquiry" (Tashakkori & Creswell, 2007, p. 4).

Hence, using mixed methods allowed the researcher to combine both qualitative and quantitative elements for the collaboration and comprehensive understanding of the phenomena being studied (Johnson et al., 2007). Moreover, the use of a mixed method approach ensured that the limits and or weaknesses of one set of data are balanced by the strengths of the other, which will be beneficial to the pragmatic researcher (Cohen et al., 2018).

The quantitative approach was used in the study to determine if there was a significant difference in the performance of the learners on the pre-tests and post-tests. The quantitative method was used to test objective theories by examining the relationship among variables (Creswell & Creswell, 2018). Hence, the relation on the extent of effectiveness of KC in developing SPS was measured using the pre-tests and post-tests so that the numbered data could be analysed using statistical procedures. The quantitative method uses impartiality to describe and measure phenomena (McMillan & Schumacher, 2014).

The learners' experiences captured qualitatively through the semi-structured questionnaire were advantageous in responding and providing clarity to the level of effectiveness in terms of gaining insight into learners doing what they were expected to do. Qualitative research is a method used to explain the meaning people attribute to a common problem (Creswell & Creswell, 2018). The qualitative section used document analysis of the KC activities and pre/ post tests and semi-structured questionnaires as methods to collect, analyse, interpreted and present information or results narratively and to give a considerable understanding of the problem (Teddlie & Tashakkori, 2009). Additionally, an understanding of the phenomenon, that is, the effectiveness of KC in developing SPS is improved by integrating different ways of knowing others and obtaining knowledge from single-method approaches (Cohen et al., 2018). As elaborated by McMillan and Schumacher (2014), the mixed method " allows investigation of different types of research questions and consequently provides rich and comprehensive data". Merging both qualitative and qualitative enables a more comprehensive and complete understanding of the studied phenomena.

4.3 Research Design

A research design refers to a selected plan for site, data and subject selection procedures that are used to respond to the research questions (McMillan & Schumacher, 2010). The sequential explanatory mixed method approach was followed in this study. McMillan and Schumacher

(2014) describe this design as categorised by initially collecting quantitative data and this is followed by a qualitative data collective phase. The concluding stage of incorporation or relating the data from the two separate constituents of data.

The first phase involved the collection of quantitative data from the pre-tests and the post-tests. Data were analysed to determine the significant difference in the performance of the learners by the comparison of the two means of the pre-tests scores and post-test scores. Qualitative data were obtained from the analysis of the Worksheets and the semi-structured questionnaires to gain a deeper understating of the quantitative data. Figure 4.1 is a diagrammatic representation of the sequential explanatory mixed methods design illustrating the interlinked phases of the research design.

Figure 4.1

Sequential Explanatory Design

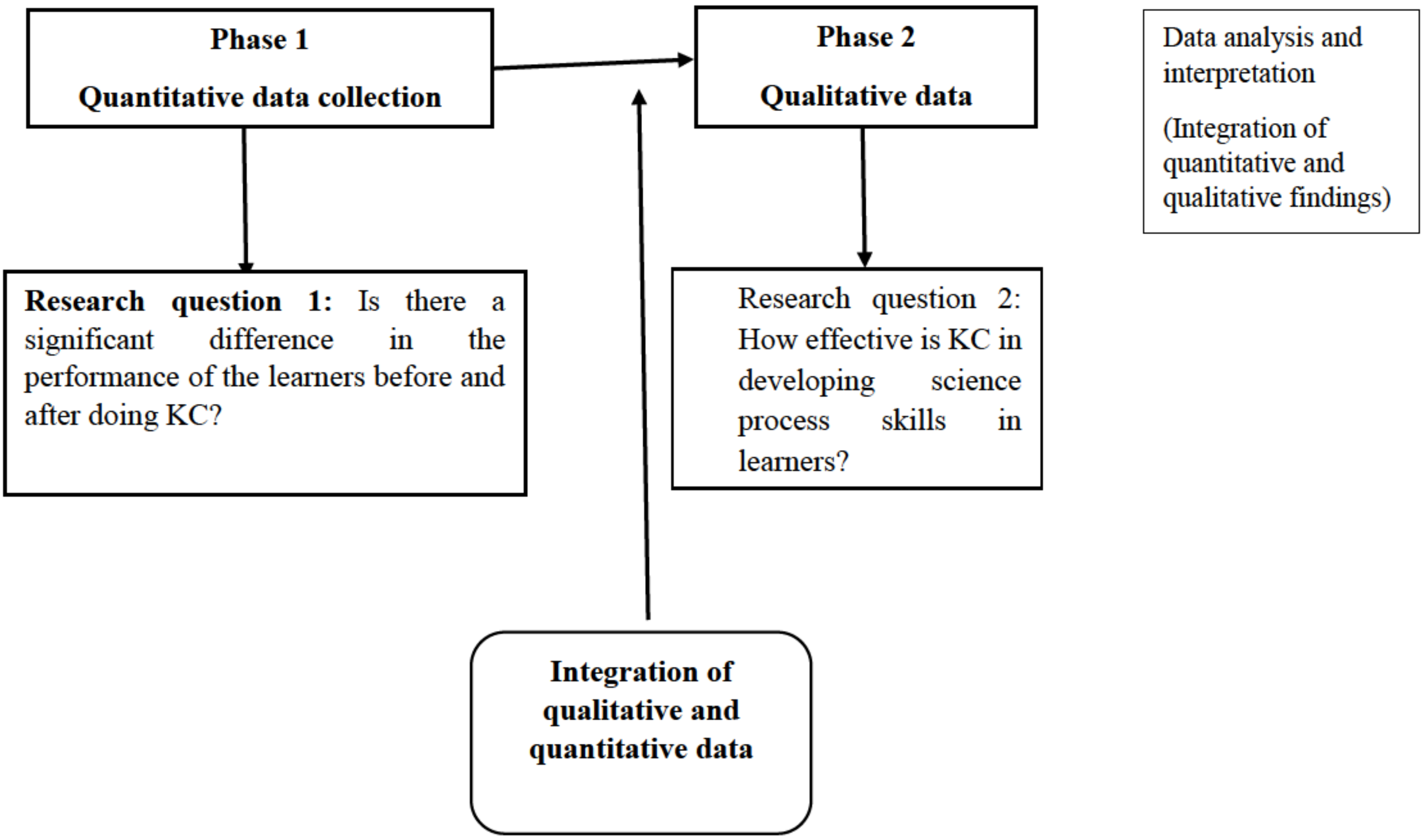


Figure 4.1 shows the interlinked qualitative and quantitative phases of data collection followed in this research. Phase one was quantitative data collection and phase two was qualitative data collection phase. Qualitative data were collected from learners who were engaged in KC and had written the tests in order to explain the quantitative data (Cohen et al., 2018). This design allowed me to analyse both qualitative and quantitative data to the ground and fully understand the level of effectiveness of KC in developing SPS.

4.4 Sampling

According to Teddlie and Tashakkori (2009), sampling is a technique that involves the selection of units of analysis for a study in a way that maximises the researcher's ability to respond to questions set forth. Similarly, Mertens (2015) posits that sampling refers to a method that is utilised by the researcher to choose a given number of people (or things) from a population. Dawson (2019) agrees that sampling is a careful selection of a research location, period, and individuals in a research field. Furthermore, the number of participants in a sample is depended on the type of research questions, the data being collected and the availability of the resources to support the study (McMillan & Schumacher, 2014). The sample was selected from the learners who were willing to participate in the study and were readily available.

- The participants were thirty Grade 12 Physical Sciences learners from one school in UMkhanyakude district. Cohen et al. (2018) affirm that thirty is generally agreed upon to be the minimum number of participants if some statistical analysis is to be performed on the data. Convenience sampling of thirty Grade 12 Physical Sciences learners was used because it allowed the researcher to select respondents that gave relevant information to the study. McMillan and Schumacher (2014) elaborate that convenience sampling allows a researcher to select participants based on their accessibility and economic considerations.

Additionally, convenience sampling is often viewed as cost effective and less time consuming (Dawson, 2019).

The sample was chosen from the learners who were willing to be involved in the study and were readily available, as it would be easy to administer and engage with participants. The school was selected because it is the school where I teach, so it would be convenient.

The sample consisted of 17 boys and 13 girls. In Grade 12, learners are expected to have gained basic skills in conducting and learning from practical activities. At their age ranging between seventeen and twenty, they would be able to critically reflect on their experiences. All the learners wrote the semi-structured questionnaires thereafter to elicit information on their experiences.

The subjective reality was related to why there was a significant difference in the performance of the learners, as well as the effectiveness of the KC activities in developing SPS in the learners.

4.5 Data Collection Methods and Instruments

The data collection method is a procedure that the researcher uses in gathering and evaluating evidence on the variables of interest in a methodical technique that allows the researcher to respond to the specified research questions and assess conclusions (Mertens, 2015). Using the mixed methods design lets the researcher to utilise various methods from both qualitative and quantitative approaches to obtain useful data. The methods used to generate data in this study were document analysis, tests and questionnaires.

4.5.1 An Overview of the KC Activities

When one often talks about the level of effectiveness of a teaching and learning activity, they are referring to the level at which it has assisted learners in learning what the teacher wants them to learn and learners doing what the teacher wanted them to do (Millar, 2009).

The CAPS document for Physical Sciences was analysed to provide an in-depth nature of the prescribed formal and informal practical work. The topic of rates of reaction was selected for engaging learners in KC under this topic. There were two KC activities that learners were engaged in after having been taught the lesson without any form of practical work. Both activities for data generation were moderated by the Physical Sciences Subject Advisor to ensure that they were fair and valid for the grade, age and language appropriate. Activities were considered to be appropriate and had information on the factors affecting the rate of a reaction. The learners were allowed to use relevant tools and reagents available to them at home. After the learners did the activities, they submitted the activities worksheet attached (Appendix D) in which they recorded the observations and conclusions of the activity. The KC activities were taken from a topic from the Matter and Materials strand under Factors affecting the rate of a reaction. The conclusions and observations were discussed during class and learners were allowed to ask questions arising from their observations and KC activities worksheet. Table 4.1 shows a summary of the KC activities that were used during the study, the topic and their description.

Table 4.1

Summary of KC Activities and Related SPS

Activity	Grade	Subject / Topic	Factor	Description	SPS linked

1	12	Physical Sciences Factors affecting rates of chemical reactions	Concentration	Learners observed the reaction of vinegar in different dilutions and baking soda	Observing Hypothesising Identifying variables Concluding Drawing of graphs Measuring
2	12		Temperature	Learners observed the reaction of ACC200 tablets in cold and hot water. Learners designed their results table for their observation	Measuring Observing Hypothesising Identifying variables Predicting Concluding Inferring Drawing of graphs

Learners were taught the topic using textbook method without any practical work, and a pretest was written. The learners were allowed time after they were taught the leasson on factors affecting rate in a chemical reaction using textbook only. The learners were re-taught the lesson and allowed time to engage in KC. Learning discusions followed for consolidation. Thereafter, without time delay, the learners wrote a post test.

4.5.2 Tests

A tests is a data collection strategy that is designed to assess understanding, intelligence or capability (Teddlie & Tashakkori, 2009). According to Cohen et al. (2018), tests are a resourceful technique for obtaining numerical data. Furthermore, tests can be used to compare learners, to see if a learner has achieved a specific criterion. The tests allowed the researcher to identify any misconceptions, a lack of understanding and a lack of SPS competence. It also gave an insight into how effective were the KC activities. Incorrect responses showed a lack of understanding and competence. Pre-tests and post-tests were used in the study as instruments for the data collection of the performance of learners.

The pre-test and post-test method involves obtaining a pre-test measure of the outcome of interest before administering some treatment to measure learners' initial understanding and competence, followed by a post-tests on the same measure after treatment occurs to determine what the learners have learnt (Cohen et al., 2018). The treatment in this study was the KC activities done by the learners. The pre-tests and post-tests had questions on how concentration and temperature affect the rate of a chemical reaction. The tests tested SPS skills competency. Learners were supposed to explain how these factors affect the rate of a reaction using the collisions theory and interpreting graphs. All the Grade 12 Physical Sciences learners were engaged in KC activities and were allowed to prepare for tests.

The SPS to be assessed in the tests are: interpreting data, identifying variables, hypothesising, and drawing conclusions. The data from the tests enabled the researcher to answer the first research question on the effectiveness of the KC in developing SPS.

Validity refers to the extent to which concepts are precisely and specifically measured using a quantitative approach. It looks at the truthfulness of the conclusions and findings of the study. McMillan and Schumacher (2014) maintain that combining both qualitative and quantitative data provides comprehensive data and enhances the credibility of the results. Credibility refers to the degree to which the findings approximate reality (McMillan & Schumacher, 2014).

The pre-tests and post-tests were checked for their relevancy, and the tests measured what they were intended to measure, as confirmed by the subject advisor for Physical Sciences. The tests were also reviewed by a local Grade 12 teacher in Physical Sciences for ambiguous questions and scrutinised for clarity so that participants understood the language used (McMillan & Schumacher, 2014). All research instruments were shared with my colleagues and experienced researchers to check the instrument's validity before administering it to respondents. The KC activities, tests and semi-structured questionnaire were all submitted to the ethical clearance committee of the University of KwaZulu Natal. After having obtained ethical clearance for the tools, piloting was conducted by the researcher.

Before the actual data collection, a pilot study was done. Piloting refers to conducting preliminary research preceding the main study, and this allows the researcher to examine the feasibility of the instruments on a larger scale (Mertens, 2015). The KC activities, tests and semi-structured questionnaires were piloted using ten Grade 12 Physical Sciences learners randomly selected from the main sample of participants. These learners were not part of the main sample to avoid issues of familiarity. Piloting enhanced the validity of the questionnaire, which ensured that the data obtained from the questionnaire were sufficient to answer the research questions. Piloting allowed the researcher to make necessary modifications on any issues or questions containing two ideas, negative wording and any misconceptions.

Various changes were made to the tests and KC activities. The first change was in the mark allocation and the breakdown of the first question of the tests. In the KC activities, ambiguous terms were clarified and simplified. The changes made were summarised in Table 4.2.

Table 4.2

Changes Made to the KC Activities and Data Collection Instruments

Activity or instrument	**Original item**	**Comments by critical reviewer**	**Changes made**
KC Activity 1: Effect of concentration of reactants on the rate of reaction KC Activity 1:	Write a balanced chemical equation for the reaction between vinegar and baking soda	Next to the name, give the chemical formulae of each in brackets	Write a balanced chemical equation for the reaction between vinegar (CH_3COOH) and baking soda ($NaHCO_3$)
	In the remaining cups, perform the following dilution as guided in the table.	Do we only perform dilution in the remaining cups?	Perform the following dilution as indicated in the table.
KC Activity 2: Effect of Temperature of	Part A: Instructions PART A: Measure 100ml of bottled water). Place it on the	Separate instructions	(i) Measure 100ml of bottled water (ii) Place it on the Ice bath

reactants on the rate of reaction	Ice bath. Measure the temperature and record it.		**(iii)** Measure the temperature and record it.
Tests	What would be observed on the scale overtime? ________. What could be the reason for the decrease in the mass? ____________________ (1) You are giving an answer Either ask first part and then ask for an explanation or tell that there will be a decrease in mass and then ask for an explanation. One mark is very little for 2 questions.	You are giving an answer. Either ask first part and then ask for an explanation or tell that there will be a decrease in mass and then ask for an explanation. One mark is smaller for 2 questions.	Questions were shortened. What would be observed on the scale overtime?
Semi-structured questionnaires	What did you like most about doing the KC experiments?	add "the" for emphasis	What did you like the most about doing the KC experiments?

4.5.3 Document Analysis

The study used document analysis to collect information associated with the effectiveness of the KC activities in promoting science process skills development. Documents contain records of information that can be valuable to research. Bowen (2009) asserts that document analysis can be used to examine and interpret data in documents in order to elicit meaning and gain understating and also develop empirical knowledge. To this effect, the post-tests were analysed and provided in-depth understanding of responses to questions. The rationale for analysing the tests was that they were an objective data source that was unobtrusive so it was possible to determine if learners were able to do what they were expected of and whether they were able to learn what they were expected to learn (Merriam & Tisdell, 2015). Document analysis was used as a method to determine the effectiveness of the KC activities in developing SPS, and this helped in answering research question two.

Document analysis of the KC activities worksheets and post-tests provided an in-depth understanding of the two levels of effectiveness of the KC activities. The first level came from the analysis of the responses to the worksheet and establishing if the learners were able to follow the given guidelines and were able to execute what they were expected to do. Level two effectiveness came from determining if the learners' understood and learnt what they were supposed to learn. The analysis further provided a deep understanding of why the KC activities are effective or ineffective.

Table 4.3 shows data about the post-test items and the related SPS embedded in the questions and contrast to what the teacher expected of learners to do or learn versus what was noted as to what the learners did or learnt. The post-test question 1 required the learners to describe an observation, as learners were expected to express what would be visually observed. The second question of the post-tests required learners to hypothesise. Despite the discussion held after the

KC activities, the researcher noticed that the learners showed difficulties in the ability to hypothesise, thus mentioning both dependent and independent variables.

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4.5.4 Semi-structured Questionnaire

According to Cohen et al. (2018), semi-structured questionnaires consist of questions and statements that are given to respondents to respond to in their words. These can be described as a transcribed set of questions that are used to assess the beliefs, attitudes, opinions and biographical data of the participants of the study. It can be used as a tool for gathering information from given varying options (McMillan & Schumacher, 2014). A semi-structured questionnaire was used to collect qualitative data in this study and was given to the learners after they had written the post-tests. The rationale for using the semi-structured questionnaire was to attain in-depth evidence on why the KC activities influenced the change in the performance of the learners.

Learners participated in a questionnaire write-up in a form of semi-structured questionnaires to help the researcher answer research question two, which is based on the effectiveness of using kitchen based general tools and chemicals to conduct and learn from a science practical activity. The semi-structured questionnaire aimed to assist the researcher in gathering complete evidence about the learner’s opinions and experiences in-depth. The semi-structured questions allowed learners to express their opinions. Besides, a time-lapse was acceptable for the participants to think about their responses (McMillan and Schumacher (2014), which allowed me to understand the underlying motivations, beliefs, attitudes and feelings of the learners regarding their experience of KC.

A Semi-structured questionnaire was given to learners after having engaged in KC activities. Thirty learners were given codes L1 to L30 and pseudonyms for anonymity were provided for qualitative and quantitative data. Participants were given consent forms that were signed by their guardians/parents. Their responses were analysed. This was done to derive the variables (Creswell & Creswell, 2018). Data from the semi-structured questionnaires were analysed to understand learners' experiences of doing KC. Data were studied to ascertain how the themes relate to each other relative to the common question on their experiences, and this was done to describe the responses of the participants.

The Semi-structured questionnaires were divided into two sections. The primary concern of this study was the lack of SPS competence in examinations. However, after engaging learners in KC activities, the learners wrote a reflection on their experiences in the semi-structured questionnaire to elicit information on how KC activities assisted them in preparing for tests and impacted their preparation for the post-tests. Learners reflected on their experiences of doing KC practical activities. The semi-structured questionnaires were guided by open-ended questions, and these allowed learners to express their opinions and experiences.

4.6 Data Analysis Procedures

This study produced both qualitative and quantitative data. The sequential explanatory research design employed is characterised by an initially collecting data qualitatively analysing to explore the phenomenon, followed by a phase of quantitative data collection and analysis to explain the relationships found in the qualitative data, with a final phase of integration or connecting the data from the two separate strands of data (Cohen et al., 2018). The scores from the pre-tests and post-tests were used to determine the standard deviation, mean and *t*-tests using Statistical Package for the Social Sciences (SPSS). The paired samples *t*-tests allowed the researcher to determine whether there was a statistically significant difference in the performance of the learners before and after doing KC activities (Cohen et al., 2018). The statistical evidence enabled the researcher to evaluate the effectiveness of KC in developing SPS.

The responses from the semi-structured questionnaires enerated qualitative data. Data were analysed to develop themes. Themes are the main characteristics of a phenomenon under study (Teddlie & Tashakkori, 2009). Qualitative analysis is a relatively systematic process of "coding, categorising and interpreting data" to provide descriptions of the phenomenon being studied (McMillan & Schumacher, 2014). Qualitative data were subjected to thematic analysis (Clarke et al., 2015). The data from the post-tests were also analysed to make sense of the data of whether the learners were able to do what was expected of them or not and whether they learnt what they were expected to learn. The effectiveness of the KC activities was determined by comparing the number of learners who successfully did what was expected of them against those who could not.

4.7 Ethical Considerations

Ethical research is research that abides by all the research ethics. Prior to conducting research, a researcher must seek approval from relevant authorities and follow appropriate procedures (McMillan & Schumacher, 2014; Mertens, 2015). Obtaining informed consent is one of the primary requirements for involving research participants. Learners and parents of learners were informed of the research to be conducted in respect of McMillan and Schumacher (2014, p. 130) where it is stated that, "no one should be forced to participate in research" therefore, learners were given consent forms for the parents to grant permission.

All the learners that took part in the study were assured of their voluntary participation in the study, and they had the freedom to withdraw their participation at any time. According to McMillan and Schumacher (2014), the researcher must take full responsibility for the protection of the rights and welfare of the subjects who participate in a study. Therefore, participants were assured of their safety. The anonymity of participants was assured and their original names would not be disclosed. Anonymity means that the reader cannot recognise the participants from the information presented in the study (McMillan & Schumacher, 2014; Mertens, 2015).

4.8 Summary

In this chapter, a description of the pragmatic paradigm, mixed methods approach and research design and a justification for their use was provided. The researcher also described how data were collected and analysed. The KC activities and tests were validated by critical reviewers. In the next chapter, the findings emanating from the tests and Semi-structured questionnaires are presented and discussed.

Chapter 5

Results and Discussion

5.1. Introduction

The purpose of the study was to explore the effectiveness of KC in developing SPS in Physical sciences learners. This study seeks to answer the three research questions which are: Is there a significant difference in the performance of the learners before and after doing KC? How effective is KC in developing science process skills in learners? What explains the level of effectiveness of KC in developing SPS in learners? This study made use of a mixed methods design. The data generation instruments used in this study were pre-tests (Appendix E), post-tests (Appendix F), a Semi-structured questionnaire (Appendix G) and KC activities (Appendix D). In this chapter, the researcher reports on the findings and a discussion of the findings. SPSS was used in the analysis of the scores. The scores from the pre-tests and post-tests were analysed to determine if there was a statistically significant difference in the performance of the learners. The difference in the scores for the pre and post-tests were calculated and analysed. Paired *t*-tests, mean and standard deviation were calculated.

Data were obtained from document analysis of the KC worksheets, pre-tests and post-tests and semi-structured questionnaires of learners' experiences of doing KC activities. This is a descriptive account of the opportunities identified for KC and contains learner responses on their experiences. The responses to the semi-structured questionnaires were used to explain the performance of the quantitative data collected from the tests. The analyses of the tests and Semi-structured questionnaires were used to describe and understand the level of effectiveness of the KC activities in promoting skills development.

5.2. Quantitative Findings

5.2.1. Is there a significant difference in the performance of the learners before and after doing KC?

Test scores obtained from the pre and post-tests were analysed to find out if there was a statistically significant difference in the performance of learners. Thirty learners wrote the pre-tests and the post-tests. SPSS was used to analyse the scores. The post-test scores were higher than the pre-tests scores. Learners improved their performance in the post-tests compared to the pre-tests. However, 7% of the learners' performance remained the same, while 7% declined. The quality of the scores in the post-tests was good. Table 5.1 shows the learners' scores for the pre-tests and the post-tests and the difference in the scores.

Table 5.1

Learners' Pre-Tests and Post-Tests Scores

Learner	Learner Pseudonym	Pre-tests /25	%	Post-tests/25	%	Difference (raw marks)
1	Masha	11	44	17	68	6
2	Tom	15	60	21	84	6
3	Jerry	10	40	19	76	9
4	Spike	16	64	20	80	4
5	Zig	18	72	23	92	5
6	Natasha	8	32	12	48	4
7	Pink	13	52	17	68	4
8	Rambo	16	64	20	80	4
9	Pat	13	52	23	92	10

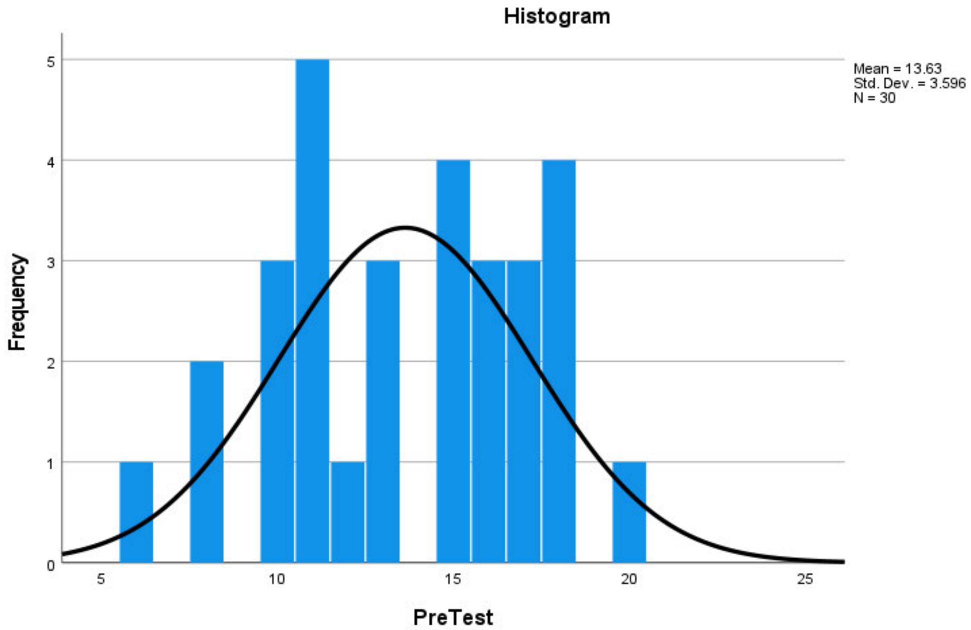
10	Russia	17	68	14	56	-3
11	Ukraine	11	44	11	44	0
12	Jack	18	72	24	96	6
13	Tim	12	48	18	72	6
14	Peter	8	32	16	64	8
15	Sammy	10	40	18	72	8
16	Sheila	18	72	22	88	4
17	Montana	11	44	19	76	8
18	Hanna	10	40	16	64	6
19	Jo	17	68	20	80	3
20	Davido	20	80	24	96	4
21	Nzimande	15	60	18	72	3
22	Eleven	11	44	15	60	4
23	Brian	6	24	15	60	9
24	Chic	15	60	18	72	3
25	Tema	18	72	21	84	3
26	Small	11	44	16	64	5
27	Slender	16	64	20	80	4
28	Calamine	17	68	22	88	5
29	Huawei	13	52	12	48	-1
30	Nova	15	60	15	60	0

These findings were summarised using the distribution curve in Figure 5.1. This figure shows the asymmetrical distribution of pre-tests findings and is positively skewed with multiple modes and the mean and median have different values. The mean for the pre-tests was 13.63.

The standard deviation of the pre-tests was 3.596 and relatively higher in relation to the mean, thus revealing that the scores of the pre-tests were widely dispersed. Figure 5.1 shows the pre-tests scores distribution and their frequencies.

Figure 5.1

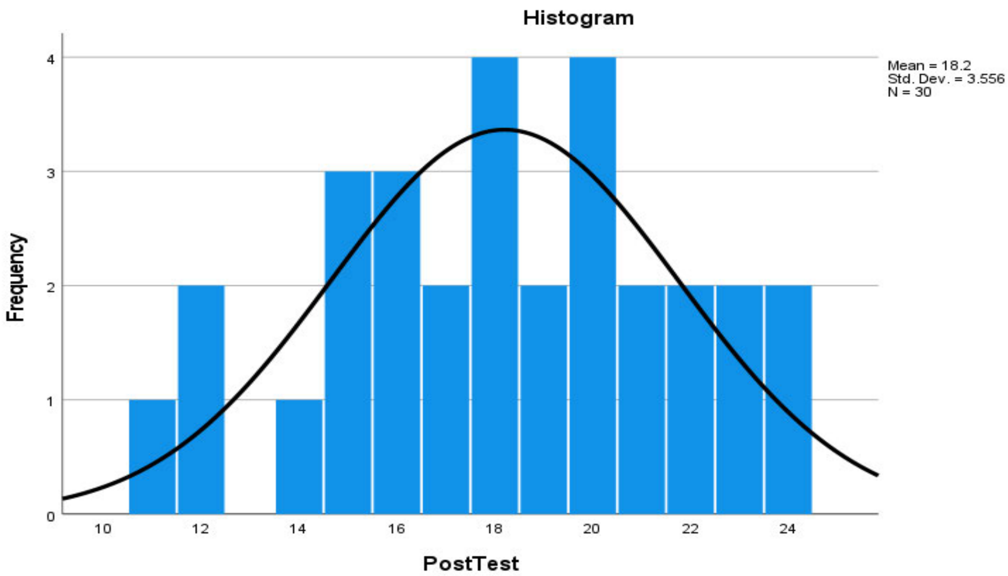
Distribution of Pre-Tests Scores



The findings of the post-tests were also summarised in the graph in Figure 6. The asymmetrical distribution of the score was obtained. The mean of the post-tests was 18.2 and a standard deviation of 3.556. The standard deviation of the post-tests was lower in relation to the mean. Figure 5.2 shows the pre-tests scores distribution and their frequencies.

Figure 5.2

Distribution of Post-tests scores and their frequencies



The contrast of the findings of the frequency distribution graphs in Figures 5.1 and 5.2 suggests that learners performed better in the post-tests when compared to the pre-tests. From the frequency distribution presented in Figures 5.1 and 5.2, it is realised that the scores of the post-tests suggest better performance in SPS tested than in the pre-tests. In general, learners had some knowledge of some basic SPS before the intervention. Hence, this sends a signal of a significant need to continuously engage learners in practical activities uniformly in the teaching and learning of science. Most questions requiring knowledge of basic SPS were achieved in pre-tests and post-tests. The post-test scores in Figure 5.2 reveal a more continuous distribution of the scores suggesting an increased even distributed scores in the post-tests. Table 5.2 shows the mean scores and the standard deviation for the pre-tests and the post-tests.

Table 5.2

Paired Samples Statistics

		Mean	N	Standard deviation	Standard Error Mean
Pair 1	Pre-tests	13.63	30	3.596	0.657
	Post-tests	18.20	30	3.556	0.649

Table 5.2 shows that the post-test mean scores were significantly higher than the pre-tests mean scores (post-tests > pre-tests 4.57). The standard deviation for the pre-tests was higher than the post-tests. This shows that the pre-tests scores were more widely dispersed than the post-test scores. The highest mark obtained in the post-tests was 24, and the lowest mark obtained was 11. The lowest was 6, and the highest was 20 in the pre-tests. The first research question in this study was addressed by determining if there was a statistically significant difference in the performance of learners in the pre-tests and post-tests.

Table 5.3 shows that the t (29) = -8.396 and the $p < 0.001$. There was a statistically significant difference in the means obtained from the pre-tests and the post-tests. This means that the difference in the performance of the learners did not happen by chance. The KC activities increased learners' competency and knowledge of science process skills and provided skills that resulted in more learners getting better marks in the post-tests. Generally, learners were able to answer more questions correctly after doing the KC activities. A point was made in the first chapter that teachers are expected to do practical work, which will ensure that learners are exposed to practical work to enable them to understand the concepts in the syllabus.

Table 5.3

Results of a Paired Samples T-tests

	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-tests - Post-tests	-4.567	2.979	.544	-5.679	-3.454	-8.396	29	< .001

5.3. Qualitative Findings

5.3.1. Effectiveness of KC in Developing Science Process Skills

The effectiveness of KC was determined by an analysis of post-test scripts and recording the number of learners who were able to do or learn what was expected of them and the number of those learners who did not manage to do what was expected of them after doing KC activities. According to Millar (2009), the effectiveness of the KC activities in developing competence in SPS was determined at two effectiveness levels. The effectiveness at level one was the alignment between what the teacher planned for learners to do and what the learners did. Effectiveness at level 1 was assessed in terms of whether the learners could set up the activity, recall their observations and whether these could link with the SPS that were intended to be learnt. Table 5.4 summarises the performance of the learners in relation to effectiveness level 1 in the pre-tests and effectiveness level 2 in the post-tests.

Table 5.4

Summary of Pre-tests and Post-tests Results

	Pre-tests					Post-tests			
Question	What learners are expected to do or learn	Number of learners who did what was expected correctly	Number of learners who did not do what was expected correctly	Mean mark	Standard deviation	Number of learners who did what was expected correctly	Number of learners who did not do what was expected correctly	Mean mark	Standard deviation
1	Describe an observation (1)	11 (37%)	19 (63%)			26 (87%)	4 (13%)		
2.1	Hypothesising (1)	9 (30%)	21 (70%)			24 (80%)	6 (20%)		
	Identifying variables (1)	22 (73%)	8 (27%)			28 (93%)	2 (7%)		
	Identifying variables (1)	24 (80%)	6 (20%)			29 (97%)	1 (3%)		
	Concluding (2)	15 (50%)	15 (50%)			27 (90%)	3(10%)		

	Observing/concluding (2)	6 (20%)	24 (80%)	13.63	3.596	20 (67%)	10(33%)	18.20	3.556
	Evaluating conclusion (4)	9 (30%)	21 (70%)			18 (60%)	12 (40%)		
2.2.	Interpretation of data (4)	4 (13%)	26 (87%)			23 (77%)	7 (33%)		
	Interpreting graphs: Drawing of graphs(4)	11 (37%)	19 (63%)			21 (70%)	9 (30%		
	Comparing/Interpreting(4)	15 (50%)	15 (50%)			25 (83%)	5 (17%)		
Total marks	25								

Table 5.5 shows data about the post-test items and the related SPS embedded in the questions and contrast to what the teacher expected of learners to do or learn versus what was noted as to what the learners did or learnt. The post-test question 1 required the learners to describe an observation, as learners were expected to express what would be visually observed. The second question of the post-tests required learners to hypothesise. Despite the discussion held after the KC activities, the researcher noticed that the learners showed difficulties in the ability to hypothesise, thus mentioning both dependent and independent variables.

Table 5.5.

Post-Tests Analysis Summary

Post-tests item and related SPS	**What the teacher expected the learners to do**	**Notes on what the learners did**
1. Describe an observation *(SPS: Observation/ inferring)*	Express expected observation.	• Described the loss of mass. • Gas escaping.
2.1. (a) write a hypothesis *(SPS: hypothesising)*	Hypothesise using dependent and independent variables.	• Gave one relationship hypothesis and not both
2.1 (b) identify dependent variable *(SPS: Identifying variables)*	Identify dependent variable	• Identified dependent variable. • Identified dependent variable as an independent variable.
2.1 (c) identify the independent variable (SPS: Identifying variables)	Identify dependent variable	• Identified independent variable. • Identified independent variable as a dependent variable.

2.1 (d) explain the purpose of controlling one variable *(SPS: Concluding)*	Explain why 1 (one) variable must be controlled. Explain why the surface area of calcium carbonate is controlled.	• Explain the response of controlled variables • Partially concluded on purpose.
2.1 (e) conclude on an observation *(SPS: Observation/concluding)*	Conclude on an observation.	• Concluded on an observation • Partially described an observation • Partially concluded.
2.1 (f) apply the collision's theory *(SPS: Evaluating conclusion)*	Logically apply collisions theory.	• Applied collisions theory. • Applied the collisions theory without logic • Partially applied the collisions theory. • Did not use the theory.
2.2. (a) Calculate the rate. *(SPS: Interpretation of data)*	Analyse the graph and calculate the rate using appropriate units.	• Calculated rate • Incomplete calculations • Omission of units
2..2 (b) Draw graphs (SPS: interpretation of data/ drawing of graphs).	Draw graphs on both axes.	• Drew graphs • Drew graphs on different axes
2..3 (c) application of collision theory *(SPS: Comparing /Interpreting)*	Apply collisions theory with logic.	• Applied collisions theory. • Partially applied collision theory.

Effectiveness Level 2: Did the learners learn what they were expected to learn?

Upon analysis of the post-tests, KC activities were found to be more effective in assisting learners to better show competence in the SPS required by the tests, as the number of learners showing competence increased significantly in the post-tests. According to the model by Millar (2009), the effectiveness of KC activities in promoting SPS competence during tests and examinations was determined on two effectiveness levels. Effectiveness level one was the alignment between what the teacher planned for the learners to do and what the teacher proposed for the learners to learn. In the first question of the pre-tests and post-tests, learners were expected to write an observation on the action of hydrochloric acid on calcium carbonate. Then, 37% and 87% of the learners were able to learn what was expected of them in the pre-tests and post-tests respectively. Most learners could describe an observation on the post-tests. In the second question of the pre-tests and post-tests, alignment was on the teacher expecting learners to give a hypothesis for the fourth experiment with the highest concentration. It was noted in this question that in the pre-tests, learners struggled with writing a full hypothesis, stating both dependent and independent variables. Seventy-three (73%) of the learners in the pre-tests and ninety three (93%) in the post-tests were able to identify the dependent variable, and 80% of the learners in the pre-tests and 97% in the post-tests respectively were learners who identified the independent variable. Learners were expected to conclude on the reasons behind controlling the state of calcium carbonate. Thus, 50% of the learners in the pre-tests were able to do what was expected of them. The learners struggled to put a clear reason for controlling one variable in an investigation. Learners were expected to describe their observations in experiment four (4) and also conclude using an observation. Hence, 20% and 67% of the learners were able to do what was expected of them in the pre-tests and post-tests respectively. Learners were more inclined on concluding the rate of the reaction without describing the observation. Learners were unable to describe an observation.

Learners were expected to evaluate their conclusions and the collision theory. Thus, 30% and 60% of the learners were able to do what was expected of them in the pre-tests and post-tests respectively. Although most conclusions given in the post-tests showed that learners could relate to the collisions theory, the learners failed to conclude logically and coherently. Learners were expected to use the collisions theory to explain the effect of increasing temperature on the rate of a reaction logically. Slender wrote: "Increasing temperature increases the number of collisions and increases the rate of a reaction". This answer omitted changes to the average kinetic energy of particles and the increased number of collisions per unit of time. The researcher noted that should learners should practice how to answer these questions in the examinations. Regarding the interpretation of data, 13% and 77% of learners were able to do what was expected of them. Although learners could relate the rate of the reaction to the gradients, most of them struggled mathematically and omitted calculation units. Learners were required to interpret and draw graphs, and 37% and 70% of the learners did what was expected of them in the pre-tests and post-tests respectively. Learners drew graphs on the same axis, but some learners omitted the labels. Fifty (50%) percent and 83% of the learners were able to compare two rates of reactions in the pre-tests and post-tests respectively.

Upon analysis of the post-tests, KC activities were found to be more effective in assisting learners to better show competence in the SPS required by the tests, as the number of learners showing competence increased significantly in the post-tests. The overall performance of the post-tests was higher than the pre-tests. The mean mark for the pre-tests was 13.63, which was lower than the post-tests at 18.20. The standard deviation of the pre-tests was 3.596, which was higher than the post-tests at 3.556. Level 2 was also assessed on whether the learners could make use of the SPS learnt during the activity using the ideas the KC activity was aiming to develop and show these SPS of the KC activity in different or related concepts. Learners could express an understanding and usefulness in developing skills.

All the learners who engaged in the KC activities followed the guidelines of the worksheet. They measured the required amounts of reagents mandatory to execute the activity. Learners repeated measurements until they were satisfied with their data. Nine (9) learners expressed this (in their Semi-structured questionnaires) as the advantage of doing KC activities in their time. Learners also used thermometers correctly. The values recorded were within the expected ranges of the temperature of water to be used. were reported but no accidents were noted. Learners were able to record their observations although varying in vocabulary. The objective of the KC activities was to create an opportunity for learners to undertake practical work so that they could use their ideas and knowledge in answering questions about doing practical work, hence, the worksheet had questions to allow learners to learn science process skills.

Effectiveness at level 1 was assessed in terms of whether the learners can design or do what the materials and objects require them to do during the KC activity, make meaningful observations as intended by the KC activity and during the KC activity, learners thought about: what they are engaged in, their observations and how they use the concepts proposed or implicit in the activity.

The learners who participated in the study also provided qualitative data. KC activities were useful in preparing for the post-tests. Although what was said by 60% of the learners did not translate to what was seen in the post-tests, the usefulness of KC activities expressed in the Semi-structured questionnaires did not manifest in the post-tests for some learners.

Six of the learners shared what they liked most about doing KC experiments. They found it interesting and it allowed them to repeat the experiments until they understood what they were doing. Learners indicated that they were able to execute activities without any problems. The KC activities allowed learners to utilise available resources to execute an investigation and were effective in both effectiveness levels 1 and 2. The quality of the answers improved in the post-tests. There were marks awarded for the accuracy of the content of the skill. In the post-tests, learners were inaccurate in their conclusions and interpretations.

5.3.2. Explaining the Level of Effectiveness of KC in Developing SPS in Learners

Qualitative data were analysed and used to explain the level of effectiveness of KC in developing SPS, and, this was done by analysing the responses to the semi-structured questionnaire written by the learners. The researcher noted that the KC activities were considered to be effective in developing SPS and the construction of knowledge and understanding of science concepts.

Qualitative data were collected to explain the effectiveness of the KC activities combined with the quantitative data. Quantitative data show that there was a statistically significant difference in the performance of learners in the pre-tests and post-tests. This section explains the level of effectiveness of KC in developing SPS in learners. Qualitative data were obtained from all the learners who participated in the pre-tests, KC activities and the post-tests. These were learners whose scores increased, declined and remained the same in the post-tests. Two of those learners were Russia and Huawei whose scores changed negatively when they wrote the post-tests. Pat had the highest increase from the pre-tests to the post-tests. Jack scored the highest in the post-tests.

The effectiveness of the KC activities can be explained in two effectiveness levels upon analysis of the responses from the questionnaire. The alignment between what the learners are intended to do and what learners do is regarded as effectiveness level one. The learner's responses to the question (Were you successful in doing what you were asked to do by the teacher?) revealed that regardless of the impact measured by the tests, all learners indicated that they were successful in doing what they were asked to do. Learners' responses to the question regarding the challenges they encountered when doing the KC experiments revealed that there were challenged by gathering tools, making accurate measurements and dealing with disturbances in the home environment. Responses obtained also revealed that learners were successful in doing what they were asked to do by the teacher, and KC activities were very useful in preparing for the tests.

The KC Activities Generated Interest in Learners

Learners revealed that it was intriguing observing the reactions unfold to completion. It was evident from what was written by learners that making observations was fun, particularly because there was the flexibility to repeat them. The interest and fun were not short-lived. This fun or interesting factor is observed as being one of the most driving factors which led to the development and learning of skills. This view is shared by Obi and Amba (2014), who suggest that KC experiments kept learners interested and active in their learning. This view is shared by constructivists. Constructivism perceives learning as an active and social process through which learners actively create meaning in their experiences by connecting them to prior knowledge (Driver et al., 1994). This benefitted the learners in learning and developing skills. Seven learners, including Jerry, narrated what he liked most about doing KC activities. Jerry said: "The KC experiments were fun, getting to play around with chemicals was great. Learning simple concepts using simple ingredients."

Five of the learners were fascinated by their observations of the simple ingredients found in the kitchen, as they had not seen the reactions before. KC activities provided learning and development of skills that helped learners to perform better in the post-tests. Interest is an important driver that can make learners more inclined to the active acquisition of science skills which can increase their attention to what is expected of them by KC activity.

These findings corroborated the reviewed literature. Engaging in active practical work in the process of teaching and learning science is enjoyable and the experiences lead to increased learner attitude, awareness and interest in science (Hofstein, 2004). Nuora and Välisaari (2019) concurred and suggested that KC is an interesting form of teaching and learning chemistry. Supplementing theory with practical work is valuable in the process of learning and understanding science (Kibirige & Hodi, 2013). The main objective of performing practical activities is to stimulate and enhance learners' understanding of science.

Freedom to Repeat Activity until Learning of Skills Occurs

Repetition is one of the main principles guiding effective learning experiences during practical work. The ability to repeat KC activity was advantageous and beneficial in learning SPS. Repeating an experiment is a standard scientific practice to improve the reliability of results. The responses to the questionnaires showed that most learners who provided reliable data repeated the activities, as long as they had reagents at their disposal. Nine learners indicated that they repeated the activities. The learners attributed the flexibility to repeat activities on their time as one of the things they like most about doing the KC activities. Russia and Huawei are learners whose performance declined in the post-tests. This decline may be caused by the challenges of making accurate measurements, finding the right measuring tool, making clear observations and limited material available at that time at home. The fact that some learners did encounter some or minor challenges may have contributed to the declining scores.

There were learners whose marks did not change. Ukraine and Nova were the learners whose performances remained the same in the post-tests. However, their responses indicated that the flexibility to repeat activities were beneficial to the learning skills. Ukraine said: "It was fun without my teacher over me. Repeating until I made all my observations" and Nova concurred:

“At first, the kitchen chemistry provided me with enough time for doing and redoing without other learners' disturbance. Usually, it is more difficult to participate in class”. Flexibility and being able to repeat the KC activities are observed as some of the main factors contributing to the learning of SPS. This could have affected their understanding of the topic and hence their ability to answer the questions correctly.

KC offered greater autonomy and flexibility

The ability of learners to do the KC activities during their time meant that they had control over the time they could do the activities. Natasha said: “Being able to do the experiments during my time at home where I can repeat the experiments until I understand what I’m doing.” This could have helped in SPS development and understanding of the concepts of the KC activity. This concurs with studies conducted by Reeves and Kimbrough (2004) and Nuora and Välisaari (2019) in that KC practical activities enriched learners’ appreciation of the significance of everyday chemistry and created passionate and enthusiastic learners.

The sense of autonomy stimulated learning amongst the learners, this meant that learners were actively involved. The KC activities can actively engage learners independently, while learning SPS and grasping new knowledge and choosing the right time to learn may also have made the KC activities effective in the learning of SPS. Tim shared the same sentiments when asked what he liked most about doing the KC activities. He said: “Mixing the chemicals myself”. This is evident that KC activities gave learners a great sense of control over their learning as they were actively involved in the processes and procedures of learning and constructing knowledge and understanding. This concurs with Millar (2004) in that the primary function of actively engaging learners in practical work is to stimulate the learning of essential SPS.

Flexibility is also suggested as a factor that allows learning of SPS to take place even outside the classroom. It allows learners to focus on learning and practicing SPS.

It is essential that while engaged in learning of science that learners recognise the relevance of science to their lives and KC activities have the potential in assisting learners realise this goal.

Diversity of Home Settings

The different home settings presented different challenges to the learners. Although all learners indicated to have been successful in doing what was expected of them, the findings suggest that some learning came after conquering challenges caused by the diversity of their home settings. Ten learners expressed challenges in gathering the required materials to execute the activities however, Montana shared that: "I had a challenge of collecting all the required materials. I ended borrowing". The flexibility of being at home allowed learners to take advantage of borrowing resources. This also enhances the class discussions after the KC activities. Every learner having different materials made it interesting to share and compare results through which the teacher can link to chemistry topics which stimulate learning and understanding.

The diverse home settings provided each learner with a familiar environment in which they could participate in practical work without being bound to curriculum time. The kitchen can be assumed to be a setting that can supplement the development of SPS and science learning. This allowed for flexibility in choosing appropriate spaces, time and convenient environments to design investigations that allow making scientific meaning.

Learners' substantive knowledge

Learners were expected to engage in KC activities designed for the topic of factors affecting the rate of a chemical reaction. The research findings indicate that KC activities improved how learners answered the questions. In the semi-structured questionnaires, learners shared that KC helped them to understand the concepts of the topic, and this was evident in the post-tests scores. One learner was Pat whose post-test marks increased shared that: "Kitchen Chemistry help me to have the clue of understanding what I have to write during exams and developing skills to understand science". From the findings, it is realised that learners benefited from experimenting with these factors practically. Learners could construct and extend their substantive knowledge of the concepts.

These findings corroborate a study conducted by Skamp (2011) which revealed that teaching through engaging learners in practical activities creates a vibrant learning environment in which an improvement in learner performance could be achieved. From the findings, it is observed that KC activities have the potential to strengthen the learning of SPS and science concepts as noted by Obi and Amba (2014) learners who are constantly engaged in KC are more inquisitive and are actively involved in the process of learning. This view is supported by Millar (2002) who elaborated that practical work not only engages learners but it necessitates for progressive learning of skills.

5.4. Discussion of the Findings

The discussion of the findings will not be done in isolation because this study utilised data qualitatively and qualitatively. These two strands complemented one another. Reference will be made both to quantitative and qualitative data for the discussion.

The first research question in this study was: Is there a significant difference in the performance of the learners before and after doing KC?

The findings from the quantitative part of the study indicated that there was a statistically significant difference in the performance of the learners before and after engaging in KC. There was a better performance of learners in the post-tests regarding the factors affecting the rate of a reaction after doing KC activities. This indicated that learners must be given opportunities to engage in this form of practical work so that the learning of science process skills can occur.

This assertion is shared by Yip et al. (2012), who suggested that meaningful learning of skills would occur if learners were sufficiently engaged in appropriately designed KC activities. The learner’s competence in SPS on factors affecting a rate of a reaction was increased. Research shows that when learners are actively engaged in practical work, handling equipment and doing experiments, they can supplement what is in the textbooks, thus stimulating the learning of practical work skills (Mji & Makgato, 2006). This is an advantage as suggested by Mji and Makgato (2006) that it improves advanced learning skills such as evaluation, analysis and problem solving and simultaneously stimulates the learning of skills.

Better performance of learners was also found by Schultz et al. (2020) whose study on KC concluded that engaging learners in relevant KC activities is valuable for foundation level chemistry learners. KC activities have a positive impact if they are related to the objectives of the lesson. Hence, careful consideration must be taken in designing the KC activities. In addition, Al-Soufi et al. (2020) indicated that learners who engaged in kitchen chemistry were very motivated and interested, hence the learning of SPS which in effect, affects the learning objectives of learning science process skills.

Better performance in the post-tests could have been because of the design of the KC activities which provided learners with opportunities to learn SPS. The KC activities were designed to stimulate scientific inquisitiveness through hands-on activities on easily accessible kitchen chemicals and materials, thus, hands-on laboratory experiments that can be performed safely at home without acquiring costly commercial laboratory equipment would be valuable (Nguyen & Keuseman, 2020). However, the curriculum lacks prescribed designs for these activities, and the researcher recommends that for continuous learner practical activities as an alternative to school-bound practical work, concise practical activities may be uniformly designed to be implemented even by schools without resources and by teachers who neglect practical work and do not create opportunities for practical activities for learners because of their inability and incompetence to handle practical work equipment and resources (Muwanga-Zake, 2004). This is suggested to encourage and clear out the misconception by learners of SPS in the literature as alluded to by Rambuda and Fraser (2004) that these will create more opportunities to actively participate in science tools to assist in the development of SPS. Schultz et al. (2020) concur in their findings that KC activities improve learner observation skills, emphasise the importance of measurement and provide some simple hands-on and relevant activities that could be done safely at home.

From the findings, some learners did not do well. The KC activities did not help them in developing SPS. This could be due to the mishandling of the materials and tools to do the activities. Some learners could have benefitted from repeating the activities. KC has been proven to be more effective in reinforcing the learning of SPS and fundamental science concepts (Karayilan et al., 2022).

This research aimed to explore the effectiveness of KC experiments in developing SPS. The findings from this study show that learners can be actively engaged in uniquely simple and carefully designed KC experiments, and learners can benefit and learn SPS from that experience. Hofstein (2004) posited that a science laboratory is a unique place that creates an environment conducive to learning skills for science. It is a place where learners can actively interact with materials and tools to affect learning skills. In this study, although the learners were required to engage in KC experimental learning at home, it provided the same opportunity that is offered by a resourced school science laboratory. Opportunities to explore and repeat availed themselves, and this assisted learners in the acquisition of SPS.

KC experiments kept learners interested and active in their learning (Obi and Amba (2014), and the chemical reactions helped them in learning SPS. This view is shared by constructivists. They assert that constructivism perceives learning as an active and social process through which learners actively create meaning out of their experiences by connecting them to prior knowledge (Driver et al., 1994). This benefitted the learners in learning and developing skills.

The KC activities required learners to design and conduct experiments on two factors affecting the rate of a chemical reaction, temperature and concentration. Practical work enables learners to develop SPS, such as observation, identifying variables, classification, inference and prediction. The KC experiments also enabled observation, identifying variables, classification, inference and prediction to be made. To that effect, KC activities can also contribute just like school-based practical work in the learning of SPS and science concepts (Yip et al., 2012).

KC can serve as an ideal solution for insufficient practical work, and learners could still benefit from science process skills development. The researcher observed that good performance can concur if relevant KC activities are carefully designed by the teacher for a particular lesson that will be effective in promoting understanding of concepts and encouraging skills development by learners. This view concurs with Skamp (2011) who emphasised that engaging learners in practical activities create an environment conducive to where improvement of learner performance could be achieved. Learners may have benefitted from discussions held after engaging in KC activities.

The second research question was: How effective is KC in developing science process skills in learners?

The second research question focussed on the effectiveness of KC in developing SPS in the study of factors affecting a rate of a reaction. The research findings indicate that KC activities enable learners to answer questions on these topics correctly. In the Semi-structured questionnaires, learners shared that KC had helped them understand the concepts of the topic and this was evident in the post-tests scores. Some learners benefitted as most of the answers they wrote were correct whilst for others, the knowledge gained could not be deduced from what was written on the post-tests scripts. The written answers showed that there was little improvement in answers given, especially in questions requiring an explanation using collisions theory.

According to the model by Millar (2009), the effectiveness of KC activities in promoting SPS competence during tests and examinations was determined on two effectiveness levels. Effectiveness level one was the alignment between what the teacher planned for the learners to do and what the teacher proposed for the learners to learn. According to constructivists, for effective learning of SPS to occur, learners must be actively engaged in the process of learning hands-on.

An analysis of the post-test scripts revealed that KC activities were effective in helping learners develop SPS for the tests. Regarding questions requiring learners to refer to or write an observation, a significant number of learners who struggled in the pre-test showed competence in the post-test.

Effectiveness level 1 was achieved when learners showed evidence of having done what was intended by the teacher, and also effectiveness level 2 was achieved by learners having learnt what was expected of them to learn, therefore, the KC activities were considered effective.

The third research question was: What explains the level of effectiveness of KC in developing SPS in learners?

The third research question explored what explains the level of effectiveness in developing SPS in learners. From the descriptions of the learners on the questionnaires, it was established that there were varied reasons why learners performed better in the post-tests. Learners repeated the activities. The observations kept learners interested and enabled learners to learn SPS. Learners were actively engaged, hence, learning of SPS took place. It also emerged that learners felt that the freedom and flexibility of doing the activity at their speed, space and time enabled opportunities for better learning of SPS other than being restricted to curriculum times at school. Learners have a sense of control over their learning. However, it was established that some learners encountered challenges.

KC activities promoted active learning of SPS, as learners were involved in class discussions on what they had done and observed. Mastering skills was possible, as learners could reflect on their designs, procedures and observations. This led to the understanding of how to use the skills in tests and on the topic of factors affecting the rate of reactions. The KC activities created opportunities for active practical work, as learners were able to learn science skills learnt in practical work science lessons.

From the responses, one could conclude that the freedom to do the experiments and make their observations at home at a time convenient to the learner is what most learners liked most about this experience. It is also evident here that the KC activities helped the learners enhance their knowledge of the science concepts and enriched learners' appreciation of the significance of everyday chemistry, thus creating passionate learners. This is because the KC involved accustomed resources (Nuora & Välisaari, 2019).

Furthermore, the learners also singled out doing a practical activity on their acts as an aid to developing skills for doing practical activities and promoting the understanding of concepts because activities involving practical work simplify science concepts and improve learners' curiosity (Makgato, 2007). There was an interaction of learners with the KC activities on various levels which could have stimulated meaningful learning. Learning occurs in various ways, as the KC activities provided a platform that catered for different learning styles. Physical or kinaesthetic learners benefitted from the “hands-on” and active learning presented by KC.

The studies reported in the literature are not all that useful in providing clear insight into the role of KC activities in developing SPS in different settings. However, the findings of this study have provided awareness about the role played by carefully designed and implemented KC activities in teaching and learning of SPS and understanding of scientific concepts. Research on the effectiveness of KC activities in developing SPS suggests how meaningful learning of skills can occur. What is needed is carefully designed KC activities in relevant science concepts across the curriculum. We need to move beyond studies that compare teaching and learning strategies, A and B. It should be noted that clear meaning and understanding of science concepts can be obtained in almost any setting, as expressed by the literature. However, these settings must be adapted to improve and stimulate effective learning with a clear understanding. Teachers should be encouraged to make professional decisions on which activities to implement to meet their educational objectives.

Learners were able to identify and use SPS in answering the post-test questions after learning the skills through KC activities. Learners displayed evidence that they could link the SPS learnt during the KC activities and discussions in answering test questions. The process of developing SPS seemed to be a combined product of frequent engagement with practical activities that stimulate learning of SPS and allow the necessity for repetition until learning occurs.

Learners lack investigation procedures and they cannot identify variables. Results showed that the frequency and the number of learning SPS opportunities presented by the teacher had a direct impact on helping learners learn SPS and the performance of the learners utilising the skills learnt in the examination. There is a need to explore the phenomenon further to understand the relationship. The key findings of the study demonstrate that the KC intervention was effective. The learning that was observed by the researcher during the discussions and conversations about the KC activities demonstrated the principles of the theory of constructivism. It is through the active mental processing of prior knowledge that learners can construct meanings of new and related concepts. Driver et al. (1994) suggested that learners create meanings from their experiences by connecting them to prior knowledge. Hence, the theories of constructivism have a duty to continuously form the foundation of teaching and learning experiences for the development of SPS. The researcher played the role of a facilitator throughout the intervention process. From the constructivist theory, it is recommended that the learning process be learner-centred and that the teacher remains a facilitator.

The learners' tests' better performance in the post-tests in SPS through practical activities shows similarities with the reviewed literature. SPS was well achieved through practical activities that allow learners to handle tools and equipment. Kibirige et al. (2014) argued that practical work is an effective approach to improving performance. It is believed that learners are likely to grasp and understand things they have engaged with, both physically and cognitively, leading to better learning (Millar & Abrahams, 2009).

Science is a subject best taught through meaningfully focused learning activities. When there are school challenges bound to practical work and insufficient resources, let us design learning activities by using materials readily found in the kitchen to teach chemistry and science. The interest and excitement exhibited when learners used their materials to make observations are valuable in the quest to stimulate learners’ development in SPS. Chemical reactions and chemistry are observed daily and should not be perceived as only existing in the laboratory. The use of KC activities enhanced skills development through which knowledge of concepts was created, hence improved performance was observed.

5.5. Summary

In this chapter, findings from the study were presented and discussed. Data were generated through the use of pre-tests, post-tests, and questionnaires and document analysis. The *t*-tests produced a statistically significant difference in the mean scores of the pre-tests and post-tests. Then, this could be attributed to the engagement of the learners in the KC activities. These activities caused a difference in the performance of the learners. Responses to the semi-structured questionnaire revealed that learners' experiences were characterised by fun and flexibility and helped the learners prepare for the post-tests. The KC enhanced active learning and enabled a deep understanding of concepts on rates of reactions. The learners were able to link chemistry to real life activities. The analysis of documents revealed that exposing learners and creating KC opportunities led to improved competence in SPS. Hence, most of the learners improved their performances in the post-tests. The following chapter provides a summary of the findings from the study, recommendations and conclusions.

Chapter 6

Summary, Recommendations, and Conclusions

6.1. Introduction

This chapter reviewed the findings, conclusions and recommendations of this research study. The focus of this study was to explore the effectiveness of KC in developing science process skills amongst high school Physical Sciences learners. Three research questions were answered by this study. The first question was: Is there a significant difference in the performance of the learners before and after doing KC? The second research question was: How effective is KC in developing science process skills in learners? The third research question was: What explains the level of effectiveness of KC in developing SPS in learners? The study generated results that addressed the research questions.

6.2. Summary of Findings

In addressing the research question, data were produced from the pre-tests, post-tests, semi-structured questionnaire and document analysis of the pre and post-tests. The findings are summarised according to the three research questions of the study.

Research Question One: Is there a statistically significant difference in the performance of the learners before and after doing KC?

The findings from this study revealed that there was a statistically significant difference in the performance of the learners in the pre-tests and the post-tests. The learners performed better in the post-tests after doing KC activities. The quality of the performance also increased.

Research Question Two: How effective is KC in developing science process skills in learners?

The practical activities are influenced by the learner's preceding information on the topic, knowledge of the use of tools and materials and how the learners conduct the practical. The findings suggest that the learner's activities match and relate to the teacher's objectives set in the KC activity, and level 1 effectiveness was achieved. The learners were able to use the SPS set by the activity, and they showed confidence and competence in SPS, thus, the KC activity was considered effective. Effectiveness level 2 was achieved in that learners could set up the KC activity and use the concepts of the KC activity to understand the scientific concepts. Learners could recall their observations and also make meaningful discussions about the activity using the ideas the KC activity was aiming to develop.

The research findings indicate that KC activities enable learners to answer questions on the Factors affecting rate of a chemical reaction correctly. In the semi-structured questionnaires, learners claimed that KC helped them understand the concepts of the topic and this was evident in the post-tests scores. Some learners benefitted, as most of the answers they wrote were correct whilst for others, the knowledge gained could not be deduced from what was written in the post-tests scripts. The written answers showed that there was little improvement in questions requiring an explanation using the collisions theory.

Research Question Three: What explains the level of effectiveness of KC developing SPS in learners?

There were varied reasons why learners performed better in the post-tests. Learners repeated the activities. The observations kept learners interested and enabled them to learn SPS. Learners were actively engaged, hence, learning of SPS took place. It also emerged that learners felt that the freedom and flexibility of doing the activity at their speed, space and time enabled opportunities for better learning of SPS other than being restricted to curriculum times at school. Learners have a sense of control over their learning. However, it was established that some learners encountered challenges.

KC activities promoted active learning of SPS, as learners were involved in class discussions on what they had done and observed. Mastering of skills was possible, as learners could reflect on their designs, procedures and observations. This led to the understanding of how to use the skills in tests regarding the topic of factors affecting the rate of reactions. The KC activities created opportunities for doing science, thus enabling learners to acquire and develop SPS.

KC offered greater autonomy and flexibility. Learners were able to take full control of their learning. This affected the learning of SPS. Learners' substantive knowledge and the different environments brought about by the diversity of home settings gave rise to the challenges. Regardless, the learners were successful in executing and repeating KC activities until learning occurred. The factors that affected the effectiveness of KC are summarised in Table 6.1.

Table 6.1

Factors Affecting the Effectiveness of KC

Level of effectiveness	Factors Affecting Effectiveness
Level 1: What the learners were expected to do versus what they actually did.	- diversity of home settings - learners' levels of interest - the level of learner autonomy
Level 2: What the learners were expected to learn versus what they actually learned.	- learners' levels of interest - learners' substantive knowledge

6.4. Recommendations

This section presents recommendations made to various education stakeholders and education levels to enhance the enactment of KC in schools, as necessitated by the findings of this study.

6.4.1. Recommendations to the Department of Education

Curriculum developers can include the use of KC as one of the suggested alternatives to schools where laboratory resource is limited. This would encourage the effective implementation of uniform KC activities. Any possible opportunity to engage learners in practical work should be utilised.

6.4.2. Recommendations to teachers

Physical Sciences teachers can integrate suitable KC activities into their teaching and planning. Learners should be given a list of household items and resources to use at home. KC should be varied. Teachers should engage in concrete discussions prior and after the KC to clear misconceptions and clarify and direct the intended learning envisaged. Teachers should encourage discussions that will make learners reflect on what they would have observed, which aids in the construction of knowledge of science concepts. Physical Sciences teachers can also cater for every learner by allowing them (learners) to share items so that they (learners) are not deprived of understanding the most important points of the activity and that learners can engage in discussions equally.

6.4.3. Recommendations for further research

There is a great need to replicate this form of study using a bigger sample comprising different settings and environments. A longitudinal study is also recommended across the Natural and Physical Sciences learners.

6.5. Conclusion

The study aimed to explore the effectiveness of KC in developing science process skills in Physical sciences. The concerns of the researcher include a lack of resources in schools to engage learners in practical work in teaching and learning of Physical Sciences. The researcher was looking for a practical alternative that can allow learners to actively engage in practical science learning activities. Teachers are the ones who determine the teaching strategies to use in delivering content in class. Teachers are willing to utilise strategies that are beneficial to learners if there is proof that the strategies work. The researcher's interest was in finding out if there was a statistical difference in the performance of learners after engaging in KC. This was attained by comparing the mean score from the pre-tests before the KC activities and the post-tests after the KC activities. Good performance means a learner understands the content under study, while poor performance indicates knowledge gaps and misconceptions.

The reason for the statistically significant difference in performance was that KC activities were enjoyable and created room for repetition until learning occurred, which encouraged learners to be actively engaged. KC generated interest and motivation to execute practical science learning activities comfortably. In this study, diverse home settings brought about different challenges. Some learners struggled to find appropriate equipment and substances to use for the KC activities.

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Appendices

Appendix A: Ethical Clearance Letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

13 September 2021

Mrs Zimele Nonkanyiso Mkhaliphi (220108388)
School Of Education
Edgewood Campus

Dear Mrs Mkhaliphi,

Protocol reference number: HSSREC/00003182/2021
Project title: Exploring the Effectiveness of Kitchen Chemistry in Developing Science Process Skills in High School Physical Sciences
Degree: Masters

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 11 August 2021 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 13 September 2022.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

Humanities and Social Sciences Research Ethics Committee
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 8350/4557/3587 **Email:** hssrec@ukzn.ac.za **Website:** http://research.ukzn.ac.za/Research-Ethics

Appendix B: Permission to Conduct Research in DoE Institutions

KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE HEAD OF DEPARTMENT

Private Bag X9137, PIETERMARITZBURG, 3200
Anton Lembede Building, 247 Burger Street, Pietermaritzburg, 3201
Tel: 033 392 1051
Email: buyi.ntuli@kzndoe.gov.za

Enquiries: Buyi Ntuli **Ref.**:2/4/8/7182

Mrs Zimele Nonkanyiso Mkhaliphi
P.O. Box 157
INGWAVUMA
3968

Dear Ms Mkhaliphi

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"THE EFFECTIVENESS OF KITCHEN CHEMISTRY IN DEVELOPING PROCESS SKILLS IN GRADE 12 PHYSICAL SCIENCES LEARNERS:",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from **10th November 2021 to 30th November 2023**.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers above.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

[redacted]

Dr M.J.B. Mthembu
Acting Head of Department: Education
Date: 10th November 2021

GROWING KWAZULU-NATAL TOGETHER

Appendix C: Letter Written to Parents/Learners and Consent Letters

Dear Parent/guardian

My name is Mkhaliphi Zimele. I am a learner at the University of KwaZulu Natal currently studying towards a master's degree specialising in Science Education under the supervision of Dr. T. Chirikure. I am also a Physical Sciences teacher at Qoshama Senior Secondary School in the Manyiseni Circuit of UMkhanyakude district. As a requirement for my degree, I will have to conduct a research study which explores the effectiveness of KC under the title: *"Exploring the Effectiveness of KC in Developing Science Process Skills in High School Physical Sciences".* Your child has been selected as one of the participants in the study.

The main purpose of this study is to establish the effectiveness of KC in developing science process skills in high school Physical Sciences. To do so, I wish to engage learners in KC activities and administer a pre-tests and post-tests to tests the acquisition of science process skills. The learners will then write a Semi-structured questionnaire to express their experiences of doing KC which will take one hour. The findings of this study will assist in determining the possible opportunities of KC for its enactment in the CAPS for Physical Sciences and thus benefitting learners who are deprived of developing science process skills to improve their performance in Physical Sciences examinations because of lack of resources and the Covid-19 pandemic health considerations.

Therefore, I would like to request the participation of your child in this study. There will be no interruption of your child's normal school programme. The school timetable will be followed. All data collected will be treated with confidentiality and the name of your child will not be mentioned anywhere in the analysis of data.

The information and research data that will be collected from learners will remain confidential and will in no way be used as school based assessment. Your child will not be exposed to any harm, risk or danger by taking part in this study. Partaking in this study is voluntary and there will be no negative consequences for refusal to participate.

The summary of the findings will be shared with the school and will remain confidential.

If you have any questions/concerns or queries related to the study, you may contact me, **Zimele Mkhaliphi, Cell: 0823174561; email: zimelemkhaliphi1987@gmail.com**

Or my supervisor: **Dr Tamirirofa Chirikure**

Tel: 0312603470; Email: chirikure@ukzn.ac.za

Or UKZN's Research Ethics Committee:

HSSREC Research Office

Tel: 031 260 8350/4557/3587; Email: hssrec@ukzn.ac.za

Please indicate on the attached form whether you permit your child to take part in this study.

Yours Sincerely,

……………………..

Mkhaliphi ZN (Ms) Cell: 0823174561/email: zimelemkhaliphi1987@gmail.com

PARENT/GUARDIAN CONSENT

I,………...the parent/guardian of ……………………………………………………………acknowledge that I have read and understood the content of the request that you have sent to me explaining clearly your purpose and intentions of your research study which is titled: "*Exploring the Effectiveness of KC in Developing Science Process Skills in High School Physical Sciences"*.

- I understand the purpose and procedures of the study contained in the information sheet.

- I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

- I understand that my child may withdraw without prejudice at any time and that his/her identification will remain anonymous throughout the study.

- I declare that my child's participation in this study is entirely voluntary and that s/he may withdraw at any time without affecting any of the benefits that s/he is usually entitled to.

- If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher, **Zimele Mkhaliphi, Cell: 0823174561; email: zimelemkhaliphi1987@gmail.com**

- If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

The supervisor:

Dr Tamirirofa Chirikure

Tel: 0312603470

Email: chirikure@ukzn.ac.za

Or UKZN's Research Ethics Committee:

HSSREC Research Office

Tel: 031 260 8350/4557/3587

Email: hssrec@ukzn.ac.za

I, therefore, **give consent /do not give consent** (please underline your choice) for my child to participate in your study.

Parent/Guardian Signature: …………………………………… Date: ……………………...

Signature of Witness:………………………………………….. Date: ………………………

Signature of Translator:……………………………………….. Date:……………………….
(Where applicable)

TO LEARNERS REQUESTING CONSENT

Dear learner,

My name is Mkhaliphi Zimele. I am a learner at the University of KwaZulu Natal currently studying towards a master's degree specialising in Science Education under the supervision of Dr. T. Chirikure. I am also a Physical Sciences teacher at Qoshama Senior Secondary School in the Manyiseni Circuit of UMkhanyakude district. As a requirement for my degree, I will have to conduct a research study which explores the effectiveness of KC under the title: "*Exploring the Effectiveness of KC in Developing Science Process Skills in High School Physical Sciences*" and will focus on exploring KC activities.

The main purpose of this study is to establish the effectiveness of KC in developing science process skills in high school Physical Sciences. To do so, I wish to engage learners in KC activities and administer a pre and post-tests to tests the acquisition of science process skills. The learners will then write a Semi-structured questionnaire to express their experiences of doing KC which will take one hour.

The findings of this study will assist in determining the possible opportunities of KC for its enactment in the CAPS for physical sciences and thus benefiting learners who are deprived of developing science process skills to improve their performance in physical sciences examinations because of a lack of resources and the Covid-19 pandemic health considerations.

Therefore, I wish to invite you to participate in this study. There will be no interruption of your normal school programme. The school timetable will be followed. All data collected will be treated with confidentiality and will in no way be used as school based assessment (SBA). Your name will not be mentioned anywhere in the analysis of data.

You will not be exposed to any harm, risk or danger by taking part in this study. Partaking in this study is completely voluntary and there will be no negative consequences for refusal to participate. Your responses will remain confidential. Your identity and the name of your school will not be revealed. A letter requesting permission will be sent to your parents asking them to grant you permission to be involved in the study. You may at any stage withdraw from the study even after giving consent. The summary of the findings will be made available to you and your school and shared with policymakers. Please, complete the attached consent form and return it to me.

Please do not hesitate to contact me, my supervisor or the Research Ethics Committee if you have any queries or seeking and clarity about this research.

Thank you for your kind assistance.

Yours Sincerely,

……………………..

Mkhaliphi ZN (Ms)

Cell: 0823174561/email: zimelemkhaliphi1987@gmail.com

Supervisor: **Dr Tamirirofa Chirikure**

Tel: 0312603470 Email: chirikure@ukzn.ac.za

UKZN's Research Ethics Committee:

HSSREC Research Office

Tel: 031 260 8350/4557/3587

Email: hssrec@ukzn.ac.za

LEARNER'S CONSENT FORM

I,………...a learner in Grade 12 Physical sciences class, **agree/ do not agree** to participate in the study entitled '**Exploring the effectiveness of KC in developing science process skills'** by Zimele Mkhaliphi.

- I understand the purpose and procedures of the study contained in the information sheet.

- I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

- I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

- If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher, **Zimele Mkhaliphi, Cell: 0823174561; email: zimelemkhaliphi1987@gmail.com**
- If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

- If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

The supervisor:

Dr Tamirirofa Chirikure

Tel: 0312603470

Email: chirikure@ukzn.ac.za

Or UKZN's Research Ethics Committee:

HSSREC Research Office

Tel: 031 260 8350/4557/3587

Email: hssrec@ukzn.ac.za

Learner's Signature: ………………………………… Date:……………………

Researcher's Signature: ………………………………… Date

Appendix D: KC Practical Activities

STRAND: CHEMICAL CHANGE

SUBJECT: PHYSICAL SCIENCES GRADE: 12

TOPIC: FACTORS AFFECTING RATES OF CHEMICAL REACTIONS

KC ACTIVITY 1:

AIM: TO DETERMINE THE EFFECT OF CONCENTRATION OF REACTANTS ON THE RATE OF REACTION. [MARKS: 25]

You will need the following:

- Vinegar
- Baking Soda
- Baking measuring cup / scoop/ tablespoon
- 6 Clear glass cups
- Bottled Water
- A stop watch

Method:

1. Rinse out 3 glasses with bottled water and wipe dry. Label them A, B, and C.
2. Add 1 tablespoon of Baking Soda in each glass.
3. In the remaining 3 cups perform the following dilution:

- Add 10 tablespoons of vinegar to all 3 cups.

In Glass1: Do not add any water

In Glass 2: add 3 tablespoon of bottled water

In glass 3: add 6 tablespoons of bottled water

4. NB: Pour the vinegar in glass 1 to contents of glass A (Record observation and record time taken for reaction to reach completion).
5. Repeat step 4 with glass 2 poured into glass B and glass 3 into glass C.

Record your results in the table below:

Glass	Vinegar: Water	Observation	Time taken / seconds (s)
A	10ml Vinegar : 20 ml Water		
B	10ml Vinegar : 30 ml Water		
C	10ml Vinegar: 40 ml Water		
D	10ml Vinegar: 50ml Water		
E	10ml Vinegar: 60ml Water		

(6)

Questions:

1. Write an investigative question for the experiment.______________________________(2)
2. Write a hypothesis for the experiment.____(2)
3. Identify the independent variable.____(1)
4. Identify the dependent variable.____(1)
5. Identify the controlled variable.____(1)
6. Write a balanced chemical equation for the reaction between vinegar and baking soda____(4)
7. Explain your observations in Glass A and C in terms of the Collisions theory ______
   ____
   ____
   ____ (4)
8. What conclusion can be drawn from the results of the experiment? ________________
   ____ (2)
9. On the same set of axes, draw a graph (not to scale) of the rate of reaction of A, B, and C(6)

Thank you for taking your time and completing this tests. Your participation is valuable to the researcher

KC ACTIVITY 2:

STRAND: CHEMICAL CHANGE

SUBJECT: PHYSICAL SCIENCES **GRADE: 12**

TOPIC: FACTORS AFFECTING RATES OF CHEMICAL REACTIONS

AIM: TO DETERMINE THE EFFECT OF TEMPERATURE OF REACTANTS ON THE RATE OF A REACTION. [MARKS: 23]

You will need the following:

- 2 Cal-C- Vita tablets
- A dish bowl with Ice cubes (Ice bath)
- Bottled water
- 2 Clear glass cups
- Thermometer
- A stop watch
- Measuring cup/ jug

Method:

1. PART A: Measure 100ml of bottled water. Place it on the Ice bath. Measure the temperature and record it.
2. Place 1 Cal-C-Vita tablet and record to time taken by the tablet to completely react. Record your observations.
3. PART B: Boil a cup of bottled water and transfer 100ml of the boiling water into a clear glass cup. Record temperature.
4. Place 1 Cal-c Vita tablet in the glass and record time taken to completely react with the water. Record your observations.

SAFETY NOTE: handle boiling water with extreme caution!!!

Results/Findings

5. Design a suitable **TABLE** to record your results and observations.____________(10)

Questions:

1. Write a hypothesis for the experiment.
   ____
   ____ (2)

2. Identify the dependent ____________and independent variable______________(2)

3. Which variable is controlled and explain why? ___________________________

   ____ (2)

4. Predict the rate of the reaction of a reaction at a HIGHER TEMPERATURE than the one recorded in PART B. Write Faster than, Slower than or Remain the same.
   ____ (1)

5. What conclusion can be drawn from the results? ___________________________
   ____ (2)
6. Explain the effect of temperature on the rate of the reaction by referring to the collisions theory.____
   ____
   ____ (4)
7. On the same set of axes, draw a graph (not to scale) of the rate of the reaction of Part A and B.____(4)

Thank you for taking your time and completing this tests. Your participation is valuable to the researcher

Appendix E: Grade 12 Physical Science Pre-Test

MARKS: 25 Time:20mins

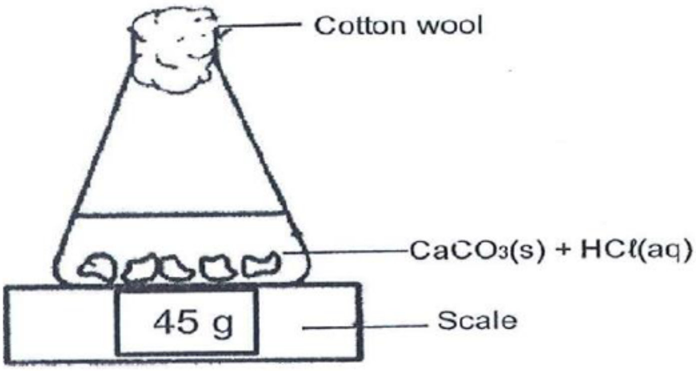
TOPIC: RATES OF REACTION AND FACTORS AFFECTING RATE

QUESTION 1

A series of experiments are conducted to investigate the effect of changing temperature and concentration on the rate of reaction between hydrochloric acid and calcium carbonate. The balanced chemical equation for the reaction taking place is:

$CaCO_3(s) + 2HC\ell\ (aq) \longrightarrow CaC\ell_2\ (aq) + H_2O + CO_2$

Each experiment is carried out in a conical flask, which is placed on top of a sensitive digital weighing balance/scale as shown in the diagram below.



1. What would be observed on the scale overtime? ________. What could be the reason for the decrease in the mass of the flask?__________________(1)
   (*Skill*: *observation / inferring*)
2. Four different experiments are carried out using the conditions indicated in the table below:

Experiment	Temperature(°C)	Concentration of $HC\ell$ ($mol.dm^{-3}$)	State of $CaCO_3$
1	20	0.1	Powder
2	15	0.1	Powder
3	30	0.1	Powder
4	20	0.2	Powder

2.1.The results of EXPERIMENT 1 and 4 are compared:

(a) Write a hypothesis for experiment 4 (*Hypothesising*)____________________
____ (2)

(b) Identify the dependent variable (*Identifying variables)*.
____ (1)

(c) Identify the independent variable *(Identifying variables)*.
____ (1)

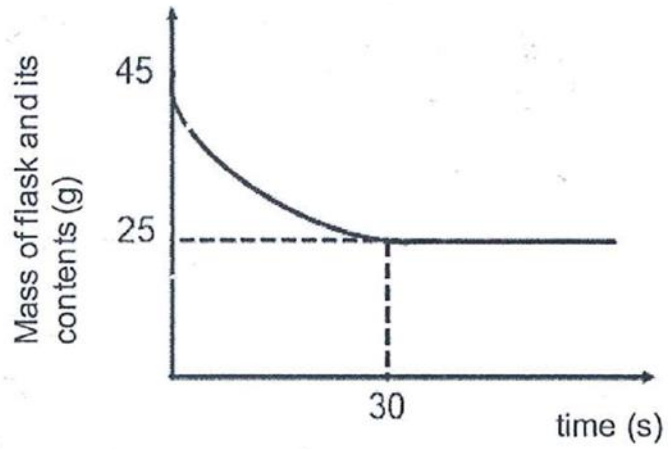
(d) Explain why the state of the $CaCO_3$ is controlled. (*Concluding)*____(2)

(e) What would be observed in Experiment 4? Explain your answer. (*Observation/ concluding)*____(2)

(f) Use the collisions theory to explain the difference in the rate of reactions between Experiment 1 and 4 *(Evaluating Conclusion*).

____ (4)

2.2.The results of EXPERIMENT 2 and 3 are compared: The results of Experiment 2 are used to sketch the graph shown below:



(a) Using the graph, calculate the rate of reaction for experiment 2 (*SPS: Interpretation of data*). (4)

(b) Redraw the graph. On the same set of axes draw sketch graphs to represent the results of EXPERIMENTS 1 and 3 (*SPS: Interpreting of data: Drawing of graphs)(4)*

(c) Use the collisions theory to explain the difference in the rate of reactions between EXPERIMENTS 2 and 3 *(SPS: Comparing/interpreting*)__________________(4)

Thank you for taking your time and completing this tests. Your participation is valuable to the researcher.

Appendix F: Grade 12 Physical Sciences Post-Test

MARKS: 25 Time: 20mins

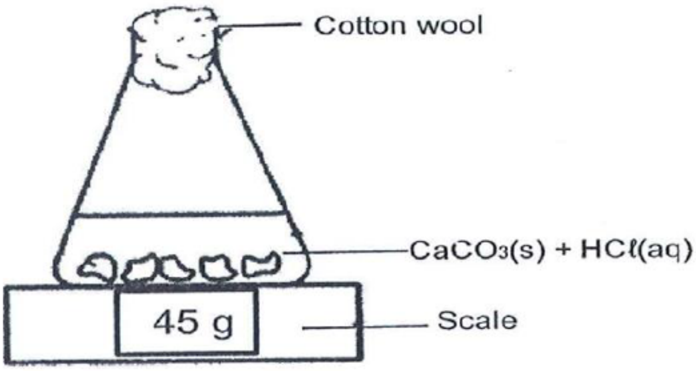
TOPIC: RATES OF REACTION AND FACTORS AFFECTING RATE

QUESTION 1

A series of experiments are conducted to investigate the effect of changing temperature and concentration on the rate of reaction between hydrochloric acid and calcium carbonate. The balanced chemical equation for the reaction taking place is:

$CaCO_3(s) + 2HC\ell\,(aq) \longrightarrow CaC\ell_2\,(aq) + H_2O + CO_2$

Each experiment is carried out in a conical flask, which is placed on top of a sensitive digital weighing balance/scale as shown in the diagram below.



3. What would be observed on the scale overtime? ____________________________(1)
   (*Skill*: *observation / inferring*)
4. Four different experiments are carried out using the conditions indicated in the table below:

Experiment	Temperature(°C)	Concentration of HCℓ ($mol.dm^{-3}$)	State of $CaCO_3$
1	20	0.1	Powder
2	15	0.1	Powder
3	30	0.1	Powder
4	20	0.2	Powder

4.1. The results of EXPERIMENT 1 and 4 are compared:

(g) Write a hypothesis for experiment 4 (*Hypothesising*)______________________
____ (2)

(h) Identify the dependent variable (*Identifying variables)*.
____ (1)

(i) Identify the independent variable *(Identifying variables)*.
____ (1)

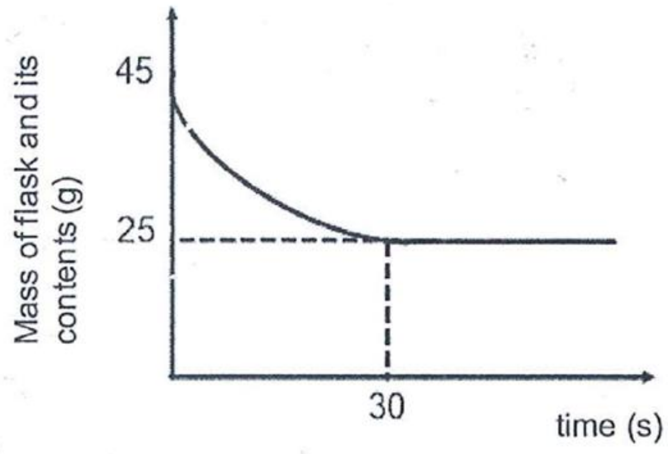
(j) Explain why the state of the $CaCO_3$ is controlled. (*Concluding)*____(2)

(k) What would be observed in Experiment 4? Explain your answer. (*Observation/ concluding)*____(2)

(l) Use the collisions theory to explain the difference in the rate of reactions between Experiment 1 and 4 *(Evaluating Conclusion*).

____ (4)

4.2.The results of EXPERIMENT 2 and 3 are compared: The results of Experiment 2 are used to sketch the graph shown below:



(d) Using the graph, calculate the rate of reaction for experiment 2 (*SPS: Interpretation of data*). (4)

(e) Redraw the graph. On the same set of axes draw sketch graphs to represent the results of EXPERIMENTS 1 and 3 (*SPS: Interpreting of data: Drawing of graphs)(4)*

(f) Use the collisions theory to explain the difference in the rate of reactions between EXPERIMENTS 2 and 3 *(SPS: Comparing/interpreting*)__________________(4)

Thank you for taking your time and completing this tests. Your participation is valuable to the researcher.

Appendix G: Physical Sciences Grade 12 Learners Semi-structured questionnaire

Dear learner,

This Semi-structured questionnaire forms part of my research proposal entitled: exploring the effectiveness of KC in developing science process skills in High school Physical Science for the degree of MEd in Science Education at University of KwaZulu Natal.

This study aims to explore the effectiveness of KC in developing SPS and determine the grade 12 learner's experiences in doing KC. The possible benefits of the proposed study are to contribute to curriculum policy development, and learner development in SPS and provide recommendations for the enactment of KC in the physical science curriculum. You are kindly requested to complete the Semi-structured questionnaire as honestly and frankly as possible and according to your personal experiences and views. No risks are associated with completing this Semi-structured questionnaire and will take approximately 20 minutes of your time. The Semi-structured questionnaire is completed anonymously. However, an indication of gender and age is required. Information will be treated with confidentiality and used for research purposes only.

Please tick the appropriate boxes.

Section A: Biographic details

1. Please indicate your grade._____

2. Are you a boy or a girl?

Boy ☐ Girl ☐

5. How old are you?

17 years and younger	
18 years	
19 years	
20 years and older	

Section B: Experiences

Please use the spaces provided below to write a 1 to 1½ page long Semi-structured questionnaire on your experience/s of doing KC activities to help you develop skills that are useful for understanding science concepts and to help you prepare for the tests and examinations.

Please refer to the following questions:

• What did you like the most about doing the KC experiments?

____

____

____

____

____

____

____

• What challenges did you encounter when doing the KC experiments?

____

____

____

• Were you successful in doing what you were asked to do by the teacher?

____

____

____

- What did you learn from the KC experiments?

- How useful were the KC experiments in preparing for the tests?

Thank you for taking your time and reflecting on your experiences.

Appendix H: Learner Responses to Semi-structured questionnaire

Responses to the Semi-structured questionnaire

(a) . What did you like most about doing the KC experiments?

Masha	*I liked that the mixing of chemicals was real. I carried it out from start till the end. And the chemicals used weren't harmful.*
Tom	*I got an idea of what happens about the rate of reactions.*
Jerry	*The KC experiments were fun, getting to play around with chemicals was great. Learning simple concepts using simple ingredients.*
Spike	*The KC experiments were more enjoyable and getting to play with the ingredients was really amusing.*
Zig	*The experiments were engaging and kept me excited every time I repeated them.*
Natasha	*Being able to do the experiments during my own time at home where I can repeat the experiments until I understand what I'm doing.*
Pink	*I have observed the reality of science and got some skills of experiments due to the understanding of chemical reactions. I've repeated it many times to get a clear vision with added knowledge. I do it at my own time at my own kitchen.*
Rambo	*I was able to repeat the investigations and make observations.*
Pat	*KC help me to have the clue of understanding what I have to write during exams and developing skills to understand science.*
Russia	*I like that I was able to repeat the activity to get understanding about what is happening in the investigation. I am doing it at my own kitchen at my own time, no teacher behind me.*
Ukraine	*It was fun without my teacher over me. Repeating until I made all my observations.*
Jack	*I'm able to do experiment at my own time.*
Tim	*Mixing the chemicals myself.*
Peter	*The experiment helped me to develop skills to do a practical activity. And I had freedom to repeat and do the activity at my own time.*
Sammy	*I liked making my own observations in a science activity.*
Shiela	*I like that the experiments taught me how to do the activity accurately and got understanding how to determine the variables regarding the experiment.*
Montana	*The experiments helped me in clarifying what I did not understand about this chapter. And I could actually do and observe in real life.*
Hanna	*Observing the different reaction rates.*
Jo	*I firstly like the fact that kitchen chemicals were reacted to obtain a chemical reaction and that rates of reactions differ from different concentrations and temperatures.*
Davido	*The vinegar experiment was fun to observe. I was able to observe and record my results. I did the experiments myself.*
Nzimande	*I like the fact that I could do it on my own space and time which allowed me to repeat it as much as I wanted to.*
Eleven	*I was learning science from the kitchen practical.*
Brian	*Experiencing real life activities in the kitchen.*
Chic	*I was doing the practical and I understood the concepts.*

Tema	*The experiments were helping to understand the topic on the rates of reactions more.*
Small	*The activities were exciting to watch and take results which helped me to answer the activity questions.*
Slender	*I liked measuring the different ingredients and observing the different rates of reactions.*
Calamine	*I liked that KC provided enough time for me to make my experiment more reliable. I liked ha the apparatus I used was home based and things I usually use at home. Practically I enjoyed myself.*
Huawei	*The experiment was relevant to understanding rates of reactions.*
Nova	*At first the KC provided me with enough time doing and redoing without other learners disturbance. Usually it is more difficult to participate in class.*

(b) What challenges did you encounter when doing the KC experiments?

Masha	*Gathering my resources. I had to use my neighbours.*
Tom	*Observing the gas forming reaction of vinegar and bicarbonate of soda.*
Jerry	*Making my observations as required by the activities so I had to repeat the experiments.*
Spike	*Comprehending some concepts was kind of difficult and the worst part was observing the reaction rates. But later on I figured out what was happening.*
Zig	*My siblings wanted to join in and observe and that somehow delayed me. Poor lighting at home during the day of the experiment.*
Natasha	*Measuring accurately. Most measuring materials available to me were estimated and not accurate.*
Pink	*I couldn't measure accurately shortage of skill, like using the instruments found in the kitchen.*
Rambo	*I was not able to measure correctly because of my measuring cups.*
Pat	*Vinegar available was insufficient to repeat as much as I wanted to.*
Russia	*I did not have enough measuring cups.*
Ukraine	*Using a thermometer was a challenge.*
Jack	*I could not measure correctly.*
Tim	*Putting everything together was a challenge*
Peter	*Measuring correctly was a challenge.*
Sammy	*Handling hot materials.*
Shiela	*It was challenging to make quick observations.*
Montana	*I had a challenge of collecting all the required materials. I ended borrowing.*
Hanna	*Collecting my ingredients to do the experiments.*
Jo	*Recording the correct time intervals and it was kind of challenging to measure the temperature on one of the reactions.*
Davido	*A challenge was getting a correct measuring cup to measure accurately.*
Nzimande	*Collecting the ingredients and materials.*
Eleven	*I did everything accordingly during the experiment.*
Brian	*Designing a table of results to record my observation.*
Chic	*I had a challenge of repeating my experiments*
Tema	*Measuring according to the required amount.*
Small	*Collecting everything I needed for the experiment, but I borrowed some of the things.*

Slender	*I had challenge when I was diluting my vinegar.*
Calamine	*Disturbance from my siblings.so they took my attention. I felt it was time consuming.*
Huawei	*Making accurate measurements for dilution.*
Nova	*Challenge was that at home their also some staff which are required of me to do. I was also busy with my other homework.*

(c) Were you successful in doing what you were asked to do by the teacher?

Masha	*Yes, I say so because my experiments matched my expectations from what I had learned in class.*
Tom	*Yes I was successful I got the results I needed to answer the activities.*
Jerry	*All that was asked of me to do was done. I was enjoying what I was doing.*
Spike	*All that was requested of me to do was done. And accompanied by a grin on my face.*
Zig	*Yes. The instructions were very clear enough for me. I was able to make all my observations.*
Natasha	*No. I had to repeat the experiment twice but I think that allowed an opportunity for me to gain more understanding because I was more careful.*
Pink	*Yes. The experiments wasn't that hard even the instructions were clear and it wasn't difficult actually everything was fantastic.*
Rambo	*Yes the instructions were clear.*
Pat	*Yes. The activities were clear enough for me to understand.*
Russia	*Yes. The activity and questions were clear.*
Ukraine	*Yes. Because the practical was clear. And I was able to make my observations. The concept of rates of reactions was easier when I was doing the practical myself*
Jack	*Yes everything was clear.*
Tim	*Yes the language used in the practical was clear for me.*
Peter	*Yes I followed the given activity for the experiment.*
Sammy	*Yes. The teacher's activity was very clear I understood what I was doing.*
Shiela	*I was successful in using resources that I was told to the activity.*
Montana	*I was able to do everything.*
Hanna	*Yes. The activities were very simple and easy to follow.*
Jo	*Yes. I followed the instructions.*
Davido	*Yes. I was successful because the instruction were clear and simple.*
Nzimande	*Yes. I managed to get all why I needed to do the experiments. And I made my observations and recorded my results.*
Eleven	*I was successful. I got all my results.*
Brian	*I was successful in doing all my activities.*
Chic	*Yes. And I enjoyed myself*
Tema	*Yes.*
Small	*Yes perfectly.*
Slender	*The experiments were clear. I did everything.*
Calamine	*It was difficult to yield the results required due to lack of understanding but I'm glad to say at the end after understanding the problem I was successful in doing the experiment.*

Huawei	*I did my activities as required.*
Nova	*At first, I was not successful, but because I was home alone, I was able to repeat and repeat the experiment as even apparatus was enough. I was successful in doing what I was required to do and the result I got was reasonable enough to make my conclusion which is based to the thing stated in textbooks we are using.*

(d) What did you learn from the KC experiments?

Masha	*I learnt that experiments are done on a daily basis. And it is not difficult to conduct any experiment just if you have the required resources at home.*
Tom	*Is that you must use the chemicals wisely because you can get hurt, and some chemicals can harm your skin.*
Jerry	*I learned the depth about collision theory and effect of temperature and concentration on the rate of reactions*
Spike	*I learnt in depth about the collisions theory and effect of temperature and concentration*
Zig	*I have also learned that if I get an opportunity I can do a practical activity and learn from it.*
Natasha	*Chemicals available at home can be used to gain understanding of science concepts.*
Pink	*I've learned that the chemicals that are used at home can be used for experiments and they are the daily participative resources. I can totally work in the kitchen if given a chance to do the experiments of chemistry.*
Rambo	*Designing a KC activity.*
Pat	*I learn that when I do more activities like this I gain more understand.*
Russia	*I learned that chemistry experiments are daily at the kitchen.*
Ukraine	*Chemicals that are available at home you can use it for investigating chemistry. Chemistry experiments are daily in the kitchen.*
Jack	*I learned how to do a practical activity.*
Tim	*I can learn chemistry at home.*
Peter	*Activities done at home can used to gain understanding of science.*
Sammy	*The experiments taught me how to a simple practical at home.*
Shiela	*I learned the effect of the two factors of rates of reactions.*
Montana	*I learned a lot on doing an experiment on my own.*
Hanna	*I learned how to do a simple practical and learn science from it. It was an exciting experience.*
Jo	*I learnt that experiments are done on a daily basis.*
Davido	*I learnt how to do a practical observe and record results so that I can make a conclusion.*
Nzimande	*I learned how to use a thermometer. I also learned how to do a science practical using kitchen tools.*
Eleven	*I learned how to do an experiment.*
Brian	*I have observed how the concentration and temperature affect a rate of a reaction.*
Chic	*I learned to do an experiment.*
Tema	*I have learnt how to design and record a table of my observation.*
Small	*I learnt how to make observations and record them.*
Slender	*Doing an experiment.*

Calamine	*What I learnt is that to perform the experiment does not require apparatus that are new to me.*
Huawei	*I learnt how to do a practical so I can make a conclusion.*
Nova	*I learnt that it is not difficult to perform an experiment. I also learnt that some experiments that we learn about in the textbooks are things that we do almost every day in our homes.*

(g) How useful were the KC experiments in preparing for the tests?

Masha	*It was very useful in such a way that it taught me about the collision theory, how particles react and how the rate of a reaction is affected by changes in temperature and concentration.*
Tom	*It helped a lot because when I was writing the tests I could remember the activity.*
Jerry	*Very useful the activities helped me to understand the concept of collision theory. Which had 4 marks in the tests. I'm now confident that I will get those 4 marks in exams.*
Spike	*Understanding the collision theory which are usually 4 marks in exams. They are way too simple to comprehend.*
Zig	*I was able to analyse tests questions using my KC experience.*
Natasha	*I was able to use my knowledge gained in doing experiments to answer the questions.*
Pink	*I was able to take in the knowledge and analysed the questions.*
Rambo	*I was exposed to questions similar to those that are asked in the exams.*
Pat	*I understood the terms and definitions of the topic more so I was able to analyse tests questions.*
Russia	*I was able to gain knowledge to answer questions in the tests. I was able to use my observations in making conclusions.*
Ukraine	*I was able to analyse a tests question using my experience of the experiment.*
Jack	*The knowledge I got from doing the practical was useful in understanding the questions of the tests.*
Tim	*I used my knowledge to answer the tests questions.*
Peter	*The experiment were very helpful to me because I was able to understand the topic more and I used them to answer the tests questions*
Sammy	*Very useful. Some questions are easier to be answered.*
Shiela	*It is very useful. The activities helped a lot in preparing for the tests.*
Montana	*I was able to understand and answer questions according to my observations.*
Hanna	*It was very useful since it became easier to attempt questions.*
Jo	*They were useful in such a way that they made me take note of the rate of reactions chapter.*
Davido	*It helped me prepare for tests questions and I used my understanding from my observation to answer the questions.*
Nzimande	*Very useful. I could relate to my observations during the tests.*
Eleven	*I was useful because it made preparing for the tests easier.*
Brian	*Very useful.*
Chic	*The experiment help me to understand the topic in the tests.*
Tema	*The activities in the experiment help me a lot in understanding the topic which made the tests easier.*

Small	*The experiments were very useful to me I got more understanding and skills to answer the tests questions.*
Slender	*I used my knowledge from the experiment to write the tests.*
Calamine	*It was very useful as I could relate the factors affecting rate and the use of collision theory to explain.*
Huawei	*It was more easier to answer the questions in the tests because it was related to the experiments*
Nova	*For the topic of rates of reactions in the textbook it is likely not to make sense but after I have done with my kitchen experiment I saw it very simple to understand factors that affect the rate of a reaction.*

Appendix I: Professional Editing Letter

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SACE REGISTERED

24 November 2022

The Effectiveness of Kitchen Chemistry in Developing Science Process Skills in High School Physical Sciences

This serves to confirm that I edited substantively the above document including a Reference list. The document was returned to the author with various tracked changes intended to correct errors and to clarify meaning. It was the author's responsibility to attend to these changes.

Yours faithfully

[redacted]

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Appendix J: Turnitin Report

turnitin

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The first page of your submissions is displayed below.

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The Effectiveness of Kitchen Chemistry in Developing Science Process Skills in High Scholl Physical Sciences

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