THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION

THE EFFECT OF VIRTUAL LABORATORY ON LEARNERS' PERFORMANCE AND ATTITUDE TOWARDS LEARNING ACID-BASE REACTIONS AMONG GRADE 11 LEARNERS:

A CASE OF SELECTED UPGRADED SECONDARY SCHOOLS IN MONGU DISTRICT

BY

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THE UNIVERSITY OF ZAMBIA
LUSAKA

DECLARATION

I, **Nicholas Sibinda**, hereby declare that this work presented herein for Degree of Doctor of Philosophy in Science Education is the result of my own work and investigations, and has not been previously submitted for any degree or diploma at this or any other University. To the best of my knowledge, this document contains no materials previously published by any other person, except where acknowledged. All references made of other authors, published or unpublished, have been duly acknowledged.

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THESIS APPROVAL BY BOARD OF EXAMINERS

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The Effect of Virtual Laboratory on Learners' Performance And Attitude towards Learning Acid-Base Reactions among Grade 11 Learners: A Case of Selected Upgraded Secondary Schools in Mongu District

By

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A Research Thesis Submitted to the University of Zambia in Fulfillment of the Requirements for the award of a Degree of Doctor of Philosophy in Science Education in the field of Chemistry Education

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DEDICATION

This Thesis is dedicated to my late beloved mother, Mrs. Judith Pumulo Tutu, who sponsored my education and my five children: Nicholas Sibinda Jr., Macphillip Sipalo Sibinda, Judith Pumulo Sibinda, Abishagy Sikopo Sibinda, and McNicholas Nasilele Sibinda.

ABSTRACT

This study investigated the effect of a virtual laboratory created using a scratch program on learners' academic performance and attitude toward learning acid-base reactions. In this study, an interactive scratch project based on the four aspects of learning modalities was created on how titration experiments could be performed including the calculation of the concentration of the titrand. This was a convergent parallel mixed study where Solomon four experimental group design was employed. Quantitative data was collected using Pre-Post-test and a Likert scale whilst interviews and observations were used to gather qualitative data. Learners in the scratch program group were instructed using a scratch program while the PowerPoint Presentation method was used in the PowerPoint Presentation group. The third group of Solomon four group design was instructed using Teacher Based Demonstration Experiment (TBDE). The results were analysed using both descriptive and inferential statistics at an alpha level of 5% and a 95% confidence level for quantitative data. Qualitative data analysis techniques such as thematic analysis were used to analyse data collected using interviews. Factor analysis followed by the Mann-Whitney U test was used to analyse the Likert scale questionnaire. At the Pre-Test level, there was no statistical difference between the scratch program and the PowerPoint presentation group in terms of attitude. However, in the post-test, there was a significant statistical difference between the two groups in terms of attitude revealing that learners taught using the scratch program exhibited better attitudes than those who were taught using PowerPoint presentation. Friedman test was used to analyse academic performance, where the pre-test revealed that there was no significant statistical difference between the two groups. However, in the post-test, there was a significant statistical difference between the four independent groups. This revealed that learners in the scratch group had performed better academically than those in the PowerPoint Presentation and Teacher Based Demonstration Experiment. It is recommended that teachers use scratch program to motivate the learners as digital platforms arouses the learners' interest. Scratch program assists learners to develop observational, inferential and experimenting skills which are fundamental in science education. The study concluded that learners to use the digital platform in the learning process. This would equip them with skills and knowledge which would result in long-term retention of scientific concepts.

Key words: Academic Performance, Scratch Program, Virtual laboratory, Effect, Acid-Base Reactions

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Contents

COPYRIGHT i
DECLARATION ii
THESIS APPROVAL BY BOARD OF EXAMINERS iii
THESIS APPROVAL BY SUPERVISORS iv
DEDICATION v
ABSTRACT vi
LIST OF TABLES xii
LIST OF FIGURES xiii
LIST OF ABBREVIATIONS xiv
CHAPTER ONE 1
INTRODUCTION 1
1.1 Overview 1
1.2 Background 1
1.3 Statement of the Problem 14
1.4 Purpose of the Study 16
1.6 Research Questions 17
1.7 Significance of the Study 17
1.8 Hypothesis 18
1.8.1 Alternative Hypothesis 18
1.8.2 Null Hypothesis 18
1.9 Justification for using both Theoretical and Conceptual Framework 18
1.9.1 Theoretical Framework 19
1.9.2 Conceptual Framework 23
1.10 Operational Definitions 25
1.11The Scope of the Study 29
1.12 Ethical Considerations 29
1.13 Chapter Summary 30
CHAPTER 2 31
LITERATURE REVIEW 31
2.1 Overview 31
2.2 The Origin of Virtual Laboratory 31
2.3 Virtual Laboratories and their Nature 34
2.4 Teacher Based Demonstration Experiment 53
2.5 PowerPoint Presentation Method 57
2.6 Phet Interactive Simulations 61

2.7 Scratch Program 66
2.8 Learners' Attitude towards Virtual Laboratories 73
2.9 Directions from Literature Review 79
2.10 Chapter Summary 80
CHAPTER 3 81
RESEARCH METHODOLOGY 81
3.1 Overview 81
3.2 Creation of Titration Scratch Program 81
3.2 Embedding of PowerPoint Presentations Videos 85
3.3 Research Paradigm 86
3.4 Research Design 89
3.5 Research Design Justification 93
3.6 Research Site and Setting 94
3.7 Research Population 94
3.8 Study Sample 94
3.9 Sampling Techniques 94
3.10 Research Instruments 96
3.10.1 Learners' Attitude Questionnaire (Likert Scale) 96
3.10.2 Lesson Observation Guide 97
3.10.3 Learners' Acid-Base Reactions Test 97
3.10.4 Learners' Interviews 97
3.11 Intervention 98
3.11.1 Intervention for the Scratch Program Group 98
3.11.2 Intervention for PowerPoint Presentation Group 100
3.11.3 Intervention for Teacher Based Demonstration Experiment Group 100
3.12 Data Collection Procedures 101
3.13 Data Analysis Procedures 102
3.14 Validity and Reliability of Pre-Test and Post-Test 103
3.15 Trustworthiness and Credibility of Observations and Interviews. 104
3.16 Chapter Summary 105
CHAPTER 4 106
RESULTS OF THE STUDY 106
4.1 Overview 106
4.2 Learners' Attitude towards Learning Acid-Base Reactions 106
4.2.1 Attitudes at Pre-Test. 106
4.2.2 Factor Analysis 107

4.2.3 Kaiser-Meyer-Olkin (KMO) Test 108
4.2.4 Total Variance Explained 110
4.2.5 Component (Factor) Matrix 111
4.2.6 Rotated Component Matrix 111
4.2.7 Mann-Whitney U Test 115
4.2.8 Attitudes at Post Test 116
4.2.9 Test of Normality 118
4.2.10 Mann Witney U Test 118
4.2 Attitudes expressed in Interviews 120
4.3 Results of Lesson Observations 124
4.4 Academic Performance Test Results 126
4.4.1 Academic Performance at Pre-Test 126
4.4.2 Test of Normality for Pre-Test 127
4.4.3 Friedman Test 129
4.4.4 Academic Performance At Post Test 130
4.4.5 Test of Normality at Post Test 131
4.4.6 Friedman Test at Post-Test Stage 132
4.5 Post Hoc Test 134
4.5.1 Comparing Scratch Program to PowerPoint Presentation 135
4.5.2 Comparing Scratch Program to Teacher Based Demonstration Experiment 135
4.5.3. Comparing PowerPoint Presentation to Non-Interventional Group 136
4.5.4 Comparing Teacher Based Demonstration Experiment to Non-Interventional 137
4.5.5 Post Hoc Test Analysis 138
4.6 Interplay Between Attitude and Academic Performance 140
4.6.1 Interplay at Pre-Test 140
4.6.2 Interplay at Post-Test 142
4.7 Summary of Results 145
4.8 Chapter Summary 146
CHAPTER 5 147
DISCUSSION OF FINDINGS 147
5.1 Overview 147
5.2 Summary of Study Results 147
5.3 Discussion of Learner's Attitude Towards Acid-Bases Reactions 148
5.3.1 Scratch Program on Learners' Attitude and Academic Performance 148
5.3.2 PowerPoint Presentation on Learners' Attitude and Academic Performance 155

5.3.3 Teacher Based Demonstration Experiment on Learners' Attitude And Academic Performance 156
5.4 Comparison of Scratch Program and PowerPoint Presentation Methods 157
5.4.1 Attitudes of Learners 157
5.4.2 Academic Performance of the Learners 164
5.5 Implications 165
5.6 Chapter Summary 166
CHAPTER 6. 167
CONCLUSIONS AND RECOMMENDATIONS 167
6.1 Overview 167
6.2 Conclusion 167
6.3 Recommendations 168
6.4 Direction for Future Research 169
6.5 Chapter Summary 170
APPENDICES 186
Appendix A: Interview 186
Appendix B: Likert Scale 187
Appendix C: Measuring Attitudes and Participation 188
Appendix D: Pre-Test 189
Appendix E: Post-Test 191
Appendix F: Interview Transcription 193
Appendix G: Marked Pre-Test Script 195
Appendix H: Marked Post-Test Script 196
Appendix I: Marked Likert Scale 197
Appendix J: Introduction Letter from DEBS 198
Appendix K: Lesson Plans 199
Appendix L: Ethical Clearance 209

LIST OF TABLES

Table 1.1	Examination analysis for upgraded and normal secondary schools
Table 4.1	Descriptive statistics at Pre-Test
Table 4.2	KMO and Bartlett's Test at Pre-Test
Table 4.3	Total variance explained
Table 4.4	Component Transformation matrix
Table 4.5	Rotated component matrix
Table 4.6	Test of Normality
Table 4.7	Mann Witney U Test Ranks at Pre-Test
Table 4.8	Descriptive Statistics at Post-test
Table 4.9	Test of Normality-attitude at Post-Test
Table 4.10	Mann Witney U Test Ranks at Post-Test
Table 4.11	The rubric of lesson observation results
Table 4.12	Test of Normality-Academic Performance at Pre-test
Table 4.13	Descriptive Statistics at Pre-Test
Table 4.14	Friedman Test at Pre-Test
Table 4.15	Test of Normality at Post-Test
Table 4.16	Descriptive Statistics at Post-Test
Table 4.17	Friedman's Test at Post Test
Table 4.18	Wilcoxon Signed Rank Test
Table 4.19	Results of Wilcoxon
Table 4.20	Wilcoxon Signed Rank Test
Table 4.21	Wilcoxon Signed Rank Test
Table 4.22	Post Hoc Analysis
Table 4.23	Mann Whitney U test at Interplay Pre-Test
Table 4.24	Friedman test-Interplay Pre-test
Table 4.25	Mann Whitney U test at interplay Post-Test
Table 4.26	Friedman test-Interplay Post Test

LIST OF FIGURES

Figure 1.1	Conceptual framework
Figure 3.1	Scratch program on acid-base reaction
Figure 3.2	Powerpoint Presentation Video
Figure 3.3	Convergence Model of Triangulation
Figure 4.1	Scree Plot at Pre-Test

LIST OF ABBREVIATIONS

ECZ	Examinations Council Of Zambia
ECE	Early Childhood Education
EFA	Education For All
VL	Virtual Laboratory
CDC	Curriculum Development Center
VRT	Virtual Reality Technology
VR	Virtual Reality
ICT	Information and Communications Technology
IVR	Immerse Virtual Reality
SBA	School Based Assessment

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter covers the background of the study, statement of the problem, purpose of the study, research objectives, research questions, hypothesis, significance of the study, theoretical and conceptual framework, operational definitions, the scope of the study and finally, the chapter summary.

1.2 Background

The natural sciences are a group of science disciplines that study the natural world and its phenomena which aim to understand the fundamental laws and principles that govern the behaviour of the universe. Natural Sciences are described as a body of theoretical, empirical, and pragmatic knowledge concerned with the world in its natural state which natural scientists produce by emphasising on explaining the verifiable, observable, and predictable events of real world phenomena. Among the branches of natural sciences is Chemistry, which has been defined as the study of the chemical composition of matter including the investigation of matter's properties, reactions and the utilisation of these chemical reactions to form new substances (Evans & Leinhardt, 2008). It is the study of the structural composition, properties and behaviour of matter. It is the study of things at the molecular level that allows for a deeper knowledge of the world, the development of methods to identify chemicals in the environment and the creation of ways to make useful materials. Therefore, in any environment, the importance of chemistry cannot be disputed as it particularly impacts daily human life in that most biological and industrial processes involve the application of chemistry. Some types of energy used in society including some industrial products come from processes that involve chemistry applications. As a result, chemistry application is an aspect that cuts across society's economic, social and cultural norms.

One of the fundamental concepts in understanding and application of chemistry is the acid-base reactions. Acid-base reactions are chemical processes typified by the exchange of one or more hydrogen ions, H^+ between species which may be neutral (molecules such as water, (H_2O) or acetic acid (CH_3CO_2H) or electrically charged(ions such as ammonium, (NH_4^+), hydroxide (OH^-) or carbonate,(CO_3^{2-}). Acid-base reactions also include analogous behaviour of molecules and ions that are acidic but do not donate hydrogen ions. For instance, Aluminium Chloride ($AlCl_3$) and Silver ion (Ag^+) acids are chemical compounds that, in water solution, the compounds possess a sharp, sour taste, metals are corroded when in contact, and have the ability to turn some blue vegetable dyes red. Bases are compounds that, when in solution, are soapy to the touch and turn some red vegetable dyes blue. Acids and bases, when reacted, neutralise each other to produce salts and water only. Salts are compounds with a salty taste but possess either of the characteristic properties of either acids or bases. Acid-base reactions, which are reversible, where the products of the reaction, can interact as well to regenerate the starting materials which were reactants. The reversibility of the acid-base reactions has brought in the concept of equilibrium. The equilibrium concept is all about reversible chemical reactions reaching a point of balance or equilibrium at which the starting materials and the products are each regenerated by one of the two reactions as rapidly as they are consumed by the other (Garry & Donald, 2017).

In Zambian school certificate chemistry, acid-base reactions is a subtopic on Acids, Bases and Salts in Grade Eleven, which is covered in both Chemistry 5070 and Science 5124 syllabi (Mweshi, 2019). The Chemistry 5070 is a pure chemistry syllabus whereas the Science 5124 syllabus is a combination of chemistry and physics. The two components of science 5124 are taught separately but combined at the final examination and both have the same scope of acid-base reactions. Currently, 5124 science paper one is physics while science paper two is chemistry. Both papers consist of three sections portioned as Section A multiple choice, Section B short answers and Section C essay type. A few years ago, there was Science Paper 3 a practical paper which comprised physics and chemistry, each with two practical questions. However, Science Paper 3 has since been scrapped and replaced with a School Based Assessment (SBA) where candidates are examined practically as they are taught. At this foundation level, understanding of the acid-base reaction is important to both teachers and learners.

Laboratory activities are important in teaching acid-base reactions, as they have provided learners with opportunities to make accurate observations and descriptions of chemical reactions (Bwalya et al., 2024). For example, learners could identify cations and anions depending on the colour of products or gases evolved from acid-base reactions. Laboratory activities enhance specific manipulative skills among learners like eye-hand coordination when the concentration of the acids and bases are measured. Besides, laboratory activities enable learners to develop logical reasoning, verify principles and facts already learnt. Clinton (2019) supports that laboratory activities sustain student's interest as well as their academic performance in science. When learners are involved in laboratory activities, they can comprehend and carry out instructions without much reliance on the teacher. These learners develop a critical attitude towards science which improves their academic performance. Mostly, these laboratory activities are conducted in specialised rooms referred to as science laboratories. Initially, when secondary schools were constructed, science laboratories were also built so that the learners consolidate theoretical knowledge by conducting practical activities. As a result, the secondary schools that were built then had a lot of infrastructure which included specialised rooms such as home economics, industrial arts and science laboratories compared to primary schools which had less infrastructure.

Schools existed as either primary or secondary during the post-independence government era from 1964 to 1991. Primary schools were running from grade one to grade seven, whilst secondary schools were running from form one to form five (later from grade eight to grade twelve). However, during the period from 1991 to 2011, the Education For All (EFA) millennium goal made the government shift from primary schools to basic schools and from secondary schools to high schools. The shift from primary schools to basic schools was to meet the goal of the citizens to attain basic education, which was from grade one to grade nine. Basic schools were running from grade one to nine, whilst high schools were running from grade ten to twelve. In the period spanning from 2011 to 2021, the government introduced upgraded secondary schools where some primary schools were converted into secondary schools (MOGE, 2019).

These primary schools lacked adequate infrastructure like science laboratories such that when they were turned into upgraded secondary schools, there was already a deficit of classroom space and specialised rooms. Therefore, the introduction of senior classes made the situation to be worse as specialised rooms to offer subjects such as sciences, home economics and technology studies were not there. To make matters worse, Early Childhood Education (ECE) was also made compulsory as the existing buildings had to be shared between the three sections (ECE, Primary and Secondary). Effective science teaching takes place when all the pupils being taught attain the desired learning outcomes in science (Muzumara, 2008). The lack of adequate specialised infrastructure in upgraded secondary schools compromised their capacity to offer effective and meaningful lessons (Kakana et al., 2021).

Due to budgetary constraints, the government was not building adequate infrastructure in these schools, hence the need to find a lasting solution to the issue of lack of science laboratories to conduct science practical activities to improve both the attitude and academic performance of the learners. The effectiveness of the learning process in learning acid-base reactions is affected negatively due to the inadequacy of infrastructure. MOE (2013) supports that learning of natural science subjects is influenced by many factors ranging from human resources, teaching and learning materials, school infrastructure, and government educational policies to the learners themselves. Most schools in urban areas have enough qualified science teachers to handle the classes whereas the internet has a lot of teaching and learning materials that could be used by both teachers and pupils.

Even with inadequate infrastructure, enrolment, insufficient teaching and learning materials in these upgraded secondary schools, a subject teacher is capable of devising alternative learner centred teaching strategies to enable pupils to attain a high retention rate of the concepts not only in acid-base reactions but also in other science related topics (Kakana et al., 2021). The inadequacy of specialised infrastructure in these upgraded secondary schools has affected the effective implementation of laboratory activities in acid-base reactions. As a result, there is a great need to find teaching strategies which would make learners to learn independently at their own pace in any suitable environment using the available digital platforms. When learners use the digital platform in the learning process, they independently improve their attitude and academic performance in acid-base reactions as theoretical knowledge would be consolidated by practice.

Furthermore, Kim-Chwee D.T. et al. (2003) reveals that many students did not understand the formation of precipitates and complex salts and acid-base reactions involved in basic qualitative analysis. The Examination Council of Zambia performance report (2023) equally indicates that there was a decrease in the academic performance of candidates in school certificates for science subjects mostly because the learners lacked practical exposure due to low-quality School Based Assessments (SBAs) and in some cases no laboratory activities were done to consolidate theoretical knowledge. Additionally, the Examination Council of Zambia (2023) reports that there was a slight decrease in performance in 2023 of 2.57%

from 29.81% in 2022 to 27.24% in 2023. Poor academic performance was observed more in the chemistry component of the 5124 syllabus. The average performance fell to 49.63 percent from 50.96 percent in 2022, showing a decrease of 1.33 percentage points in Chemistry 5070 (ECZ, 2022). This data indicates that the usual method of teaching the topic on acid-base reaction might be ineffective in fostering its understanding (Kim-Chwee D.T. et al. 2003). Yunus (2018) supports that learners exhibit positive attitude towards learning acid-base reactions when they conduct experiments in the laboratory. The lack of laboratory activities coupled with the impact of the 2020 COVID-19 pandemic and school closures on the 2023 candidates made the academic performance drop. Therefore, it is important to introduce virtual laboratories in schools so that future candidates do not face similar challenges of not having practical activities when schools are in recess due to pandemics. Table 1.1 shows the academic performance of normal and upgraded secondary schools in the Science 5124 Examination Council of Zambia syllabus for grade twelve (school certificate) final examination since 2019.

Table 1.1

Academic Performance in Science 5124

SN	SCHOOL	TYPE	2019	2020	2021	2022	2023
01	Kanyonyo	Upgraded Secondary	20%	18%	20%	27%	21%
02	Imwiko	Upgraded Secondary	22%	30%	17%	24%	19%
03	Mandanga	Upgraded Secondary	-	-	18%	21%	23%
04	Katongo	Upgraded Secondary	-	-	57.1%	17.8%	48.8%
05	Malengwa	Upgraded Secondary	-	32%	29%	27%	23%
06	Kambule	Normal Secondary	72%	68%	81.7%	63%	72%
07	Holycross	Normal Secondary	98%	92%	96%	88%	94%
08	St. Johns	Normal Secondary	90%	94%	80%	92%	88%
09	Sefula	Normal Secondary	80%	76%	88%	82%	90%
10	Western Province National Performance		56.3%	68.96%	73.3%	47.84%	45.68%

Source: School Guidance office

The data from Table 1.1 was collected from both upgraded secondary schools and the ones that were established as already secondary schools (Normal Secondary) within the same catchment area of Mongu Central District. It is observed from Table 1.1, that the normal secondary schools have been performing well in Science 5124 as compared to the upgraded secondary schools. The schools which were established as secondary schools have enough infrastructure such as science laboratories as compared to the upgraded secondary schools. Due to the lack of science laboratories in upgraded secondary schools or inadequate laboratory apparatus and reagents, practical activities are rarely performed (Kakana et al., 2021 & ECZ, 2023). The introduction of upgraded secondary schools has increased the rate of failure in science because of inadequate laboratory apparatus and equipment (Kakana et al., 2021). This failure rate in Science 5124 in these upgraded secondary schools has contributed to the province having a low pass rate as attributed from Table 1.1. In a chemistry lesson, learners are active when they are engaged in their learning process by seeing, observing and doing.

The various scientific laboratory activities provide learners with meaningful learning (Ausubel & Tumei, 2004). Basaraba (2012) supports that laboratory activities increase learners' interest and abilities for the acquisition of scientific concepts. However, in some cases, laboratory activities have some limits and problems, particularly in the developing world, despite being very important in science education for learners. For instance, the following are some major problems encountered when using science laboratory based learning; laboratory activities are expensive when experiments are being carried out as equipment, apparatus and reagents have to be arranged, time is consumed on laboratory activities to be planned and executed. Overcrowded classes tend to pose a challenge during laboratory activities when checking learners' performance (Kakana et al., 2021). Lack of laboratory equipment or inadequate laboratory apparatus limits the teacher's ability to conduct a simple laboratory activity. However, teachers are sometimes compelled to conduct laboratory activities in crowded groups or perform a demonstration because of equipment limitations, inadequate time allocated to a particular topic and at other times due to insufficient experimental conditions.

The consideration of these factors which limit the effectiveness of delivering hands-on experiments to learners provides inevitable opportunities to seek appropriate alternative teaching and learning methods. Among these teaching methods is the utilisation of educational technologies, particularly using the computer in supporting laboratory activities, which could be a logical one since learners like playing with technological gadgets, hence connecting them to their learning in the classroom (Balkan et al., 2002). The common technology platform used in these upgraded secondary schools with computer laboratories is teaching learners using the PowerPoint presentation method.

PowerPoint presentations consist of several individual slides. Slides may contain text, graphics, sound, movies, and other objects, which may be arranged freely (Mason & Hlynka, 1998). The presentation can be printed, displayed live on a computer, or navigated through at the command of the presenter. For larger audiences the computer display is often projected using a video projector. Slides can also form the basis of webcasts. Microsoft PowerPoint is an easy to use tool for most teachers with a wide range of options to use when teaching various concepts especially in the field of science and particularly teaching acid-base reactions using videos. PowerPoint presentation method has the freedom to customise the template. It offers various customisable templates with different designs, tools and effects that help the users or presenters to the subject matter and learners. It also allows integration of multimedia elements in PowerPoint, like high-quality videos, audio, and animations. Multimedia technology has been shown to elicit the highest rate of concept retention and result in shorter learning time (Ng and Komiya, 2000; Hofstetter, 1995). This, therefore, reveals that virtual laboratories' introduction in these upgraded secondary schools would benefit the learners to attain a high retention rate of the concepts learnt for a longer period as it promotes independent learning.

In this regard, virtual laboratories emerged as a response to the challenges of providing practical, hands-on experience to learners in various scientific disciplines (Dede, 2009). Virtual laboratories are interactive, digital simulations of activities that typically take place in physical laboratory settings. Virtual laboratories simulate the tools, equipment, tests and procedures used in chemistry, biology, physics and other disciplines. Virtual laboratories allow learners to conduct various experiments without constraints on place or time, in contrast to the constraints of real laboratories (Amagai, Cordon, & Liu, 2001).

Ayas and Tatli (2010) support that virtual laboratories earlier on were created to prove theoretical knowledge but lately, there are able to be turned into environments where learners freely discover knowledge as individual or in groups. As a result, virtual laboratories emerged as an alternative solution for the problems of the instruction of applied courses. The virtual laboratory may enable learners to access valuable practical lessons which would make them perform better in their final examinations. The shift towards online and technology-driven education prompted the exploration of virtual environments to simulate real-world laboratory experiences. These virtual laboratories include simulations, games, scratch program and YouTube videos that enable learners to have an insight into events, laboratory activities and processes that would have been unavailable to them through interactive engagement. Initially, computer simulations were mainly used in applied fields, such as in the aviation industry and medical imaging, however, these technologies have now been introduced in the science classrooms (Bozkurta & Ilika, 2010).

Presently, scientific and technological competencies are vital to the nation's future development. The weak performance of learners in chemistry reflects the uneven quality of current science education (Bekar, 1996). Although young children come to school with innate curiosity and intuitive ideas about the world around them, science classes rarely tap this potential because the learners rarely learn by doing an exercise.

The poor academic performance of candidates in chemistry is often blamed on inadequate laboratory practical exposure during the teaching of chemistry mostly due to the hazardous nature of some chemistry experiments. As a result, there was a need to search for teaching methods such as virtual laboratories that would be used to overcome this practical constraint which has continued to engage researchers. In the Zambian context, however, very few schools have adequately equipped laboratories whereas the majority of schools have equipped laboratories and most of the upgraded secondary schools have no laboratories, hence the need to introduce virtual laboratories, which would enable the learners to learn science practically.

Herraez, (2022) supports that laboratory activities in chemistry education increase learners' interest in the subject covered in the class and help them understand the concepts, virtual laboratories would enhance the aforementioned aspects when used as a supplement to physical laboratory activities or in the absence of physical laboratory activities. Herraez (2022) states that learners using virtual laboratories might be assessed by placing them in real-world scenarios and asking them to apply their knowledge to solve them. Other assessment procedures for the learners would include self-assessment, pre-test and post-test scores. Virtual laboratories simulate a real laboratory environment and processes, and are defined as learning environments in which students convert their theoretical knowledge into practical knowledge by conducting experiments (Allen et al., 2005).

Therefore, virtual laboratories provide an opportunity for learners to bridge the gap between theoretical knowledge and practical application, enhancing their understanding of scientific concepts and fostering critical thinking skills. This was supported by Eli and Widiyanti (2020) that animations improve the academic performance of the learners in acid-base reactions. As a result, the virtual laboratories could be the best alternative and supplement to schools with inadequate laboratory instruments and apparatus, more especially because these schools have computer laboratories. These computer laboratories could be timetabled such that science lessons are offered using virtual laboratories. This would enable the learners to learn science concepts practically in schools which do not have adequate science laboratory infrastructure and would serve as a supplement to traditional instruction in those schools which have laboratories. In all the science subject areas, practical learning activities are recommended (Curriculum Development Centre [CDC], 2013). It has been argued that natural science subjects are best taught and learned through practical methodologies such as experimenting, demonstration, field work and problem solving (CDC, 2013). Currently, computer science has been introduced as a practical subject to equip learners with essential knowledge in the science of the computer and coding which is a foundation for scratch program creation. (MOE, 2023)

The interactive learning environment which is created when animations and simulations are used for learning abstract concepts makes learners become active in the learning process, thereby enabling learners to connect, construct and more easily understand difficult concepts (Demirci, Douglas, & Yayincilik, 2003). In this context, appropriate simulations and animations based on scientific concepts generally increase the learning speed by allowing learners to express their real reactions easily. Actually, well designed simulations and animations provide learners with better opportunities to express their cognitive skills, which includes choosing appropriate simulations from the computer screen. These opportunities allow learners to come up with their own hypothesis about the topic and create their own methods of problem-solving (Colletta & Chiappetta, 1989; Erni, Jimmy & Roza, 2019).

According to Balkan et al., (2002), complex concepts taught to learners are made simple by the use of animations and simulation, hence providing the learners with opportunities of learning by doing. In this regard, therefore, the inclusion of Virtual Reality in laboratories, which is also referred to as the use of virtual laboratory or simulation programs, overcomes some of the problems faced in traditional laboratory applications and makes positive contributions to reaching the objectives of an educational system (Sung & Ou, 2002). Some apparatus and reagents needed for learning some concepts in the physical laboratory are not available. Hence, a virtual laboratory can be a supplement to those schools which have conventional laboratories but the equipment and apparatus are inadequate.

Virtual laboratories provide students with meaningful virtual experiences and present important concepts, principles, and processes. Using virtual laboratories, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences for those learners in schools with convectional laboratories and those in upgraded secondary schools which have no conventional laboratories. Moreover, the interactive nature of such teaching methods offers a clear and enjoyable learning environment (Banda & Chola, 2021).

Many experts have called for a new approach to science education, based on recent and ongoing research on teaching and learning. Virtual laboratory techniques is becoming the training environment. In this approach, virtual laboratories such as simulations and games could play a significant role by addressing many goals and mechanisms for learning science, conceptual understanding, science process skills, understanding of the nature of science, and scientific discourse including argumentation and identification with science and science learning (Basaraba, 2012).

To overcome the burden of inadequate laboratory equipment and apparatus, virtual laboratory activities provide a platform for learning science through interaction with digital simulations and games. It considers the potential of digital games and simulations to contribute to learning science in schools in informal out of school settings and everyday life. Achuthan et al., (2015) support that virtual laboratories are an Information and Communication Technology (ICT) based initiative that is becoming more prevalent in learning institutions used for improving classroom education.

These virtual laboratory activities application is in line with the connectivism philosophy that supports laboratory methods as being ideal in the provision of knowledge that can be gained not only through individual learner experience and observation but also by connecting to other sources of knowledge (Jone, 2018). It is generally acceptable in the entire world that the idea of using learner-centred connectivist-based teaching methods is widely appreciated since teacher-centred teaching approaches or traditional instructional methods have given insufficient opportunities for learners to constructively connect their learning to their fellow learners, other objects and other individuals (Eli & Widiyanti, 2020).

Therefore, connectivism theory suggests that learners should combine thoughts, theories and general information in a useful manner. It accepts that technology is a major part of the learning process and that our constant connectedness gives learners opportunities to make choices about their learning. As a result, it's a learner centred approach as it enables learners to be wholly involved in the learning process as a teacher acts as a facilitator. Even in the absence of the teacher, the learners are able to connect to the technological devices and learn on their own the concepts that are required. Hence, virtual laboratories enhance learner-centred approaches. Eliciting the capabilities of individual learners, intelligence and creative thinking can only be achieved through the implementation of learner centred teaching methods (Callaghan et al., 2010).

Virtual laboratories enable mastery of competencies such as observation and critical analysis, which requires the use of teaching approaches that attract, and sustain learners' interest and connect school learning and the real world. Therefore, connectivism learning theory provides a useful and functional framework from which to attain the goals of science education and brings new practices to instruction as learners connect to technological gadgets such as computers and smartphones to gain some knowledge and skills (Flan, 2023).

Learning is a continuous process that lasts for a lifetime. Hence, it makes learning while one is engaged in work related activities no longer separate. In many situations, they are the same. Technology is altering (rewiring) our brains (Brown, 2002). Learners come to learning situations with a variety of knowledge, feelings, and skills, and this is where learning should begin, hence connecting to their experiences. This knowledge exists within the learner and is developed as individuals interact with their peers, teachers, and the environment. Learners construct understanding or meaning by making sense of their experiences and fitting their ideas into reality.

Most of the practitioners and educational researchers admit that Virtual Reality (VR) technology has proved to bring new insights in support of the education of learners. Duffy and Jonassen (1992) claimed that technological education practices were to be couched in the constructivist paradigm because connectivism theory was not discovered then. As a result, several universities began the process of introducing technology into education, where students would use technological gadgets such as computers in learning scientific skills and concepts. Therefore, the universities' initiatives resulted in developing systems that resemble the real world as much as possible and are as experimental as possible, hence the connectivism theory coming into play. Sung and Ou (2002) states that the advantage of a virtual laboratory is its ability to support connectivist learning activities. As learners use technological gadgets, they are made to connect various concepts during their learning using the software and applications which are embedded in these technological gadgets. As they play with the technological gadgets, the learners are learning concepts in chemistry. Therefore, as an experiential learning tool, virtual reality is an active knowledge-creation environment. However, connectivism would be a better paradigm because it believes that knowledge does not only exist in human beings but also in other objects where an individual can always connect to get knowledge.

Despite connectivism being a learning theory that describes the process of knowledge acquisition, connectivist practices should be applied both in the classroom and outside to provide and support the active knowledge-acquisition process (Johnstone & Shuaili, 2001). Most of the concepts of science lessons are abstract in nature. Therefore, to enable learners to understand such concepts, it is necessary to use connectivism based learner-centred approaches. In spite of the concept of ‘‘learning by doing’’ not necessarily being new, allowing pupils to learn by being wholly involved in their knowledge acquisition is a totally departure from traditional methods of teaching (Bruner, 1990). In this context, well equipped science laboratories are a cardinal part of educational infrastructure to facilitate learners' gain of experience in learning science concepts. This is more concerned with chemistry as it is a branch of natural sciences where the importance of laboratory activities in instructional approaches is explicitly understood.

A study by Callaghan et al., (2020) on some carefully designed multimedia materials indicated that there was an effect on learners coping with the high volume and complexity of information presented in lessons. For example, learners who were exposed to narrated, animated lecture videos in an introductory electricity and magnetism topic significantly improved their understanding of the concepts, as measured by their performance on tests of learning. The use of digital platforms in the teaching and learning process improves the retention of concepts by the learners which in turn improves the attainment of the learning outcomes.

In another similar study by Brookes et al., (2009) which was based on the measure of how much conceptual acquisition learners gain from lesson demonstrations in introductory physics courses, online video versions of lecture demonstrations were found to be more effective. Moreover, students' self-reported enjoyment was measured to be the same for both. The videos arouse the interest of the learners to continue learning as repetitions are done consistently.

Virtual laboratories are better used in schools because primarily they help resolve the high cost of laboratory apparatus and reagents (Achuthan et al., 2015). As a result of the high cost of reagents and apparatus, most upgraded secondary schools have insufficient apparatus and reagents, therefore, bringing in the virtual laboratories would help supplement the acquisition of knowledge and skills in the learners. Therefore, virtual laboratory seems to be an increasing interest in experimentation due to risks, unreliability and other complications involved in the science laboratory. The lack of laboratory activities to supplement theoretical concepts has resulted in poor academic performance of the learners in most upgraded secondary schools in science based.

Appropriate practical work enables students to think and act scientifically. The scientific method is developed with the infusion of laboratory experiments interrelated with theory (Saravanakuma, 2013). Nowadays, due to the unavailability of real objects for laboratory activities in these upgraded secondary schools, a teacher should depend on technologically mediated laboratory skills in learning practical skills in science based subjects. Multimedia based virtual laboratory replaces the real objects in the science laboratory and it helps students and teachers to enhance their laboratory skills in learning science (Saravanakuma, 2013).

Therefore, this study created titration laboratory activity using scratch program software to assist in mitigating the high cost of apparatus and reagents, inadequate infrastructure and staff so that the academic performance of the learners improve in these upgraded secondary schools. The created titration laboratory activity was based on the learning or perceptual modalities of how the mind primarily processes information through visual (seeing), auditory (hearing), kinesthetic (moving), and tactile (touching) (Willingham, 2005). The scratch project took into account all four learning modalities. Scratch program uses coding which assists learners to concentrate on generating concepts that build their intellectual abilities. The project depicted how the apparatus was arranged during the titration experiment laboratory activity, including the reagents needed. Besides, the scratch program enhances learner collaboration and communication as the created scratch programs are shared. The titration scratch program created had animations of the real titration experiment and a narration that grade 11 learners were using. The examination council of Zambia is keen on wet laboratory assessment therefore the created titration laboratory activity would equip learners with the necessary knowledge and skills to use in a wet laboratory activity.

1.3 Statement of the Problem

The candidates who wrote Chemistry 5070 syllabus in 2022 lacked observational and inferential skills when answering question A10 on acids, bases and salts-titration which required experimental skills from School Based Assessment (SBAs)(ECZ, 2022). The candidates could not suggest a suitable indicator or predict the colour changes of an indicator to distinguish between an acidic and an alkaline solution from a common practical on titration which could have been conducted during SBAs. Another challenge was determining appropriate acid-base indicators and concentrations in titration experiments.

These challenges suggest a need for more frequent School Based Assessment (SBA) practice in schools. Yunus (2018) supports that most of the learners show a positive attitude towards learning acid-base reactions when laboratory activities are included in the learning process. The attitude towards learning acid-base reactions is influenced by the media. Kim-Chwee et al. (2003) also reveals that many learners did not understand the formation of precipitates, complex salts and acid-base reactions involved in qualitative analysis. This, therefore, indicated that candidates faced poor application of scientific skills that should have been developed through the implementation of SBAs. ECZ (2023) supports that candidates failed to apply the scientific skills from the SBA practical activities to the already analysed practical examination questions which were in a theory question paper.

Additionally, ECZ performance reports (2017-2023), indicated that candidates had difficulties in tackling some chemistry questions particularly those which require laboratory activities. For example, question 12 from 5070, 2023 Chemistry Paper 2 was on acid base reactions where understanding of acids, bases and salts was tested. ECZ (2023) revealed that 79 percent of the candidates misunderstood the rephrased definition of a base as an electron donor, contrary to an acid which donates a proton. The candidates need practical work to cement the concepts which they learn theoretically as theory papers also contain some already analysed practical questions.

This concern about poor academic performance of learners in chemistry has led to several suggestions for improvement. Unfortunately, these suggestions revolve around inappropriate teaching methods and inadequate laboratory practical exposure as the major causes of students' poor performance in chemistry. Kim-Chwee et al. (2003) indicates that the method of teaching the acid-base reactions might be ineffective in fostering its understanding. Chemistry, being an activity oriented subject, should be taught experimentally. Due to inadequate infrastructure and inadequate chemicals, there is need to supplement wet laboratory activities by virtual laboratory so that learners acquire necessary skills and knowledge.

Furthermore, virtual laboratories contribute to holding the students' interest, developing a deeper understanding of the content, and increasing the retention of new information, and the emphasis in simulation games is on conceptual understanding rather than the memorization of facts (Limniou et al., 2007). Bopitiye (2024) supports that attitude towards chemistry significantly influences student achievement. The virtual laboratories aim at improving learners' conceptual understanding and attitudes towards chemistry ensuring that curriculum and teaching practices are engaging and relevant to learners' interests and experiences.

However, virtual laboratories are limited in giving a full sensory experience of a real laboratory such as weird noises, smells, random errors and faulty machinery besides requiring computers with high specifications to stimulate phenomena with full details. This makes virtual laboratories to be unable to provide certain real experimental situation experience to the learners. Scratch is a visual block based programming language that doesn't provide any progression to text based programming languages making Scratch program not the best option for students who would like conduct text based programming language.

Zudonu (2013) states that students' achievement mean scores in practical chemistry (acids and bases) were significant when virtual laboratories were used. Saravanakuma (2013) supports that multimedia based virtual laboratory enhances pupils' experience, understanding, skills and enjoyment of science. Therefore, student's achievement is a function of teaching methods. ECZ (2023) recommended that schools to implement practical tasks regularly to enhance practical understanding of concepts. Learners should conduct practical experiments in schools to reinforce theoretical knowledge.

In fact, ECZ (2022) recommended to schools to provide learners with more opportunities to engage in practical work frequently to help build their confidence. Practical work should be incorporated into the teaching in a way that complements theoretical learning which may include simulations. School Based Assessments (SBA) must include high quality questions that test higher order thinking skills. The emphasis was the need for learners to conduct practical experiments in schools to consolidate theoretical knowledge. Virtual laboratories would provide a platform for learners to be able to conduct these laboratory activities either within the school or away from school to have meaningful learning on acid-bases reaction. Arda et al. (2005) support the use of computer aided learning methods for teaching acids and bases.

Most of the schools in the urban area of Mongu have computer laboratories making the use of scratch program to be a feasible arrangement. The study developed a scratch program on titration to supplement the titration experiment done when teaching acid-base reactions. Virtual laboratory has been the new venture to better education which would provide extensible laboratory experience to learners as it complements the usual theoretical education which happens in schools (Achuthan et al., 2015).

1.4 Purpose of the Study

The purpose of the study was to create a titration experiment using a scratch program as a virtual laboratory activity and determine its effect on the learner's attitude and academic performance in acid-base reactions.

1.5 Research Objectives

This study was guided by the following research objectives:-

1. To determine the difference in attitude of the learners taught acid-base reactions using a scratch program and those taught using a PowerPoint Presentation method.
2. To determine the differences in academic performance between learners taught acid-base reactions using a scratch program and those taught using a PowerPoint Presentation method.
3. To analyse the interplay between attitude and academic performance of learners taught acid-base reactions using scratch programs and PowerPoint presentations.

1.6 Research Questions

The following research questions guided the study:-

1. What are the differences in the attitude of learners taught acid base reactions using the scratch program and those taught using the PowerPoint Presentation methods?
2. What are the differences in academic performance between learners taught acid-base reactions using a scratch program and those taught using a PowerPoint Presentation method?
3. How do attitude and academic performance interplay between learners taught acid-base reactions using scratch program and PowerPoint presentations?

1.7 Significance of the Study

The findings of the study would be useful to learners of chemistry as they would be able to learn some basic concepts on their own at their own pace and try to develop other virtual laboratories for teaching other challenging topics in chemistry. It would also arouse the interest of both the learners and chemistry teachers, such that it would generally be inevitable to embrace laboratories as a worthwhile alternative approach towards effective teaching and learning.

It is furthermore hoped that the use of virtual laboratories would enable the teachers of chemistry to deliver lessons practically using digital platforms for meaningful learning to take place. It would also help the teacher to arrange learning tasks from simple to complex using simulation games and YouTube videos, including scratch programmes.

1.8 Hypothesis

The following hypothesis would be used to guide the study:-

1.8.1 Alternative Hypothesis

1. There is a significant difference between the attitude of learners taught using a scratch program and those taught using the PowerPoint Presentation method.
2. There is a significant difference in academic performance between learners taught acid-base reaction using a scratch program and those taught using a PowerPoint Presentation method.
3. There is a significant interplay between attitude and academic performance exhibited by learners who were taught acid-base reactions using a scratch program and PowerPoint presentation.

1.8.2 Null Hypothesis

1. There is no significant statistical difference in attitude between the learners taught acid-base reactions using the scratch program and those taught using the PowerPoint Presentation method.
2. There is no significant statistical difference in academic performance between learners taught acid-base reaction using a scratch program and those taught using a PowerPoint Presentation method.
3. There is no statistically significant interplay between attitude and academic performance exhibited by learners who were taught acid-base reactions using a scratch program and PowerPoint presentation.

1.9 Justification for using both Theoretical and Conceptual Framework

The research questions under study tackle both attitude and academic performance as dependent variables which interacted with the teaching methods as independent variables. Attitude is a social aspect that is dealt with by examining participants' worlds and actions in narrative or descriptive ways more closely representing the situation as experienced by the respondents (Brewer & Hunter, 2006). This brings into perspective the qualitative research which stresses the socially constructed nature of reality where social experience is created and given meaning. Therefore, a theoretical framework has been used in this study as themes and theories emerged from the interviews and observations conducted.

Quantitative research on the other hand looks at the relationship of variables using statistical analysis (Brewer & Hunter, 2006). This is the reason for using conceptual framework in this study as the relationship of the variables is linked. The two paradigms are based on two different ways of understanding the world which are related to the way research data is collected (word versus numbers) and the perspective of the researcher(perspective versus objective) and discovery versus proof. This study being mixed, therefore, uses both the theoretical and conceptual framework.

1.9.1 Theoretical Framework

The study was set on the conceptualisation of virtual laboratories, which is underpinned by the connectivism theory of 2005 established and advanced by Siemens, as well as being consistent with the needs of the twenty-first (21st) century as a digital era (Dasgupta, 2013). Connectivism is a learning theory for the digital age (Siemens, 2008). The connectivism theory takes into consideration modern learning opportunities such as the use of networks, technology and the diminishing half-life of knowledge. It combines relevant constituents of available learning theories, social structures, and technology to create a powerful theoretical construct for learning in the digital age (Gredler & George, 2005). The development and usage of virtual laboratories and how they promotes learning, particularly on the use of relevant methods in promoting effective teaching and learning, rests on the connectivism principles (Adlong, 2009 & David, 2018).

As compared to other theories, connectivism has been used to justify the current paradigm shift in teaching approaches in the 21st century (Brennan, 2012; Kropf, 2013). The shift from the transmission of knowledge by the teacher to actively involving learners in the process of constructing their meaning of scientific concepts and knowledge would bring about meaningful learning. As a result, there would be a shift from rote memory to meaningful learning that promotes understanding of the concepts of acid-base reactions (David, 2018).

Learning is a process that occurs within nebulous environments by shifting the core concepts that an individual has no entire control over. Learning, which is defined as knowledge possession that is actionable and can be found outside an individual (within an organization or a database), is focused on specialized information sets by connections, and these connections enable individuals to learn at their own pace (Adlong, 2009). Connectivism theory is, therefore, driven by the understanding that decisions are based on the development of technological facilities (Bell, 2010). New knowledge is continuously being generated and acquired. The ability to draw distinctions between important and unimportant information is vital in an individual. The ability to recognize when new information alters the landscape based on decisions made yesterday is also critical. All these methods promote a learner centred approach.

One of the principles of connectivism theory is connectedness which starts with an individual learner. The Personal knowledge is composed of a network, which feeds into organizations and institutions, which in turn feed back into the network, and then continue to provide learning to individuals (Becky, Choi & Juan, 2013; Kropf, 2013). This cycle of knowledge development (personal to network to organization) allows learners to remain current in their field through the connections they have formed.

Connectivism theory recognises that learning is not limited to the classroom walls but encourages students to connect with and learn from the wider community by inviting experts to share their knowledge and experiences with the class (Bell, 2013). This can be done by using scratch program, video conferencing, and guest blog posts or even in person visits. As a result, learning would need a connection from either other people or from digital gadgets available.

Dunamais and Landauer (1997) explored the phenomenon that learners tend to possess much more knowledge than appears to be present in the information to which they have been exposed. Connectivist focus was provided in stating the simple notion that some domains of knowledge contain vast numbers of weak interrelations that, if properly exploited, can greatly amplify learning by a process of inference (Dunamais & Landauer, 1997). The value of pattern recognition and connecting an individual's "small worlds of knowledge" are apparent in the exponential impact provided on our learning.

Social network analysis, which is the interaction of learners within their learning environment, is an additional element in understanding learning of acid-base reactions in a digital era. Kleiner (2002) explores Karen Stephenson's "quantum theory of trust" which “explains not just how to recognize the collective cognitive capability of an individual in the learning institution, but how to cultivate and increase the cognitive abilities of an individual. Within social networks, hubs are well-connected learners who can foster and maintain knowledge flow. As learners learn practical skills, they are wholly involved like pragmatists are involved in discovering knowledge practically. Their interdependence results in effective knowledge flow, enabling a personal understanding of the state of activities in a scientific laboratory. One way teachers implement connectivism is through the use of classroom social media. For example a class scratch program group watsap can be used to share information, engage in discussion or announce homework tasks to perform using the scratch program. In this regard, learners are assisted to have a boost in classroom engagement and open the lines of discussion among learners and teachers.

When the connectivist theory is employed in the learning process, the learners are able to acquire knowledge and skills from their fellow learners and the technological gadgets in their environment (Brennan, 2012). The learners would have hands-on activities to be wholly involved with, even at their homes, as they play with technological devices such as phones and computers. As the learners are responsible for their learning, they assimilate concepts that are required not only for their examinations but also for survival.

The learner centred approach has been the guiding principle in the implementation of the Zambian curriculum framework 2013 (MOE, 2013). According to the MOE (2013) states that the learner centred approach develops learners’ ability, attitudes, skills and values to work independently and helps them to take responsibility for their learning. Thus, curriculum implementation requires teachers and educators to use teaching methods that promote active learner participation and interaction through the design and delivery of lessons with high-quality learner-centred experiences (MOE, 2013). This implies that teachers need to develop sound practical skills in their learners through virtual laboratories for the effective implementation of the curriculum.

A teacher constructs his or her knowledge of teaching and how learners can easily understand a certain topic through experience and connects it such that knowledge can be tapped from technological gadgets when needed. The teacher guides students through the problem process while allowing them to use their own mental capacities to find solutions. The teacher relies heavily on the principle that learning and knowledge rest in the diversity of opinions possessed by the learners in the classroom setting. Learning may reside in non-human appliances. The capacity to know more is much more critical than what is currently known from his or her experiences to model what he or she considers to be exemplary teaching practices based on the connectivism approach.

The teacher's connectivism model of effective teaching and learning of science is dependent upon understanding that learning is a process of connecting specialized nodes or information sources (Brown, 2002). This can be achieved through a vibrant and well constructed virtual laboratory which can enhance the learners' understanding through the use of a virtual laboratory on acid-base reactions. For instance, a scratch program on titration can be used to teach the formation of salt from acid-base reactions during the neutralisation reaction. This would include the calculation of concentrations from the acid-base reactions used in the salt formation (Armoni, Meerbaum & Mordecai, 2015). Connectivism theory would enable learners to connect to technological devices to enhance the acquisition of knowledge and skills. This means that, even in the absence of teachers, learners would be wholly involved in the learning process. It would also extend to their homes, where they would be learning to use simulations, scratch programs, YouTube and games.

The scratch program is essential in the learning process as it enables all learners with different learning styles to be effectively included in the learning process. The scratch program has all the learning modalities such that all learners are met at their needed point. The scratch program, in this case, the titration program, enables the learners to visualise the process at the same time as to have an auditory narration of the animation and to some extent have a feel of the apparatus being used (Coffield et al., 2004). As a result, all the learners can learn effectively in the process. The scratch program enables pupils to connect to a computer as plug and play such that the connectivism theory is enhanced. As the learners connect to computers, they acquire the necessary practical skills and knowledge from digital gadgets. Therefore, the relationship between connectivism theory and the scratch program is plug and play so that necessary practical skills and knowledge are learnt to enhance the learners' practical knowledge.

1.9.2 Conceptual Framework

The conceptual framework captured the key concepts and their relationships in this study. The framework integrated the modified virtual laboratory model, pragmatism and the acid-base reaction content. Both pragmatism and the scratch program emphasise on project based learning, play-based learning, experimentation and experiential learning. As a result, they complement one another such that play and plug of the scratch program brings in the experience the learners would have and above all hands-on which is experimentation (Stephenson, 2004). Figure 1.1 shows the conceptual framework showing the relationship of Virtual Laboratory to attitude and academic performance.

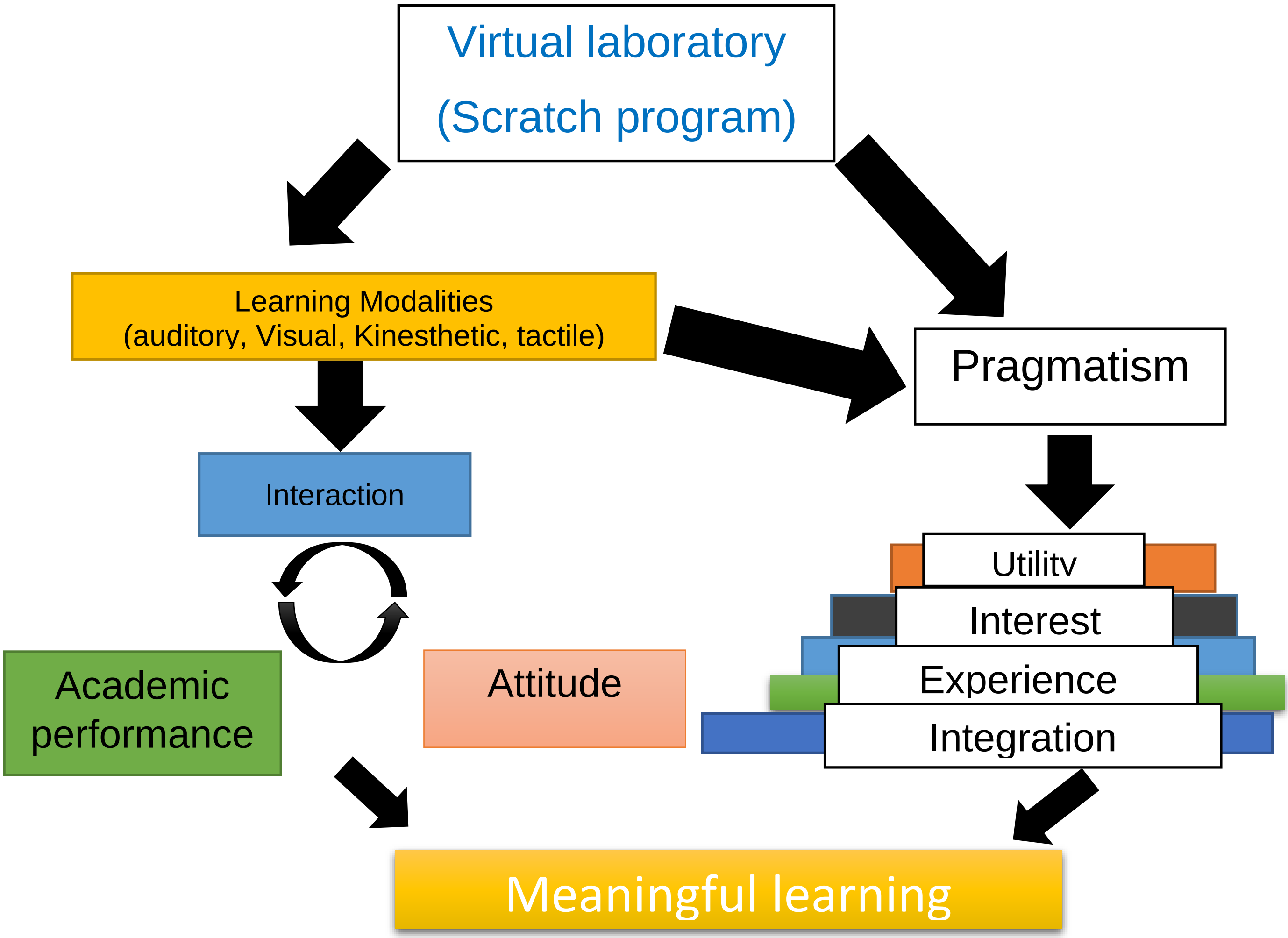

Figure 1.1: Conceptual Framework

The virtual laboratory which is an independent variable feeds into the learning modalities of the learners, which affects the way learners acquire skills and knowledge. The pupils learn better when the learning modalities they possess are incorporated into the learning process. The theory of learning modalities stipulates that when a teaching instruction is designed that match a student's "style" of learning, they should learn better (Coffield et al., 2004). The assumption is that once a specific learning modality is identified, an instruction that best fits such a learning style can be designed. The visual learner when following the video in the scratch program would understand the concepts of acid-base reactions when presented to them visually. The auditory learner would acquire knowledge and skills when listening to the embedded audio. Scratch program is interactive such that adjustments of concentrations between acids and bases can be done by the learner. Therefore, the kinaesthetic learner would understand best when they can touch/feel what is being presented to them using the scratch program.

Scratch program promotes meaningful learning in the teaching and learning process. Meaningful learning is promoted as the learners acquire both collaborative and communication skills by sharing the created scratch projects of acid-base reactions (Coffield et al., 2004). Meaningful learning refers to the concept that learned knowledge, for instance, facts are fully understood by the individual learner and that the learner can connect the relationship between the specific concepts to other facts.

Scratch program enables the learners to develop critical thinking and problem-solving skills as they create scratch projects. In the titration scratch project, computational thinking skills were developed when calculating the concentration of the acid which neutralised the base. When a scratch program is used in the learning process, learners are encouraged to use digital gadgets whenever they have one by their side as they become independent learners.

Besides the scratch program improving the practical aspect of the acid-base reactions, it's also a philosophy that underpins the mixed study method of this research. If the scratch program is well implemented, it would enable learners to have high scores in the post-test as compared to the PowerPoint presentation method where the learners were interacting with the slides which did not match with the various learning modalities. It is expected that a scratch program promotes repetition which results in the learners having a long-term memory and retention of concepts. When a scratch program is used in the learning process, learners are encouraged to use digital gadgets whenever they have one by their side. This would result in meaningful learning taking place among the learners. Meaningful learning is the dependent variable in this study.

Scratch program promotes neuron connection because the learners practice what they learn theoretically (Andrew, 2022). When the learners perform virtually how to conduct a titration experiment then they do it physically resulting in pragmatic learners. The connection between theory and practice assists in the growth and strengthening of connections between neurons. This results in the learners being taught acid-base reactions to have better academic performance and high attitude levels as compared to the group that was taught using PowerPoint presentation.

Above all, there exists an interplay between attitude and academic performance. When learners' attitude improves, it results in the learners having an improved academic performance whether the scratch program is used or the PowerPoint presentation approach is used. The use of digital gadgets results in the learners being highly motivated, such that their attitudes towards learning are improved, which results in an improvement in academic performance.

1.10 Operational Definitions.

Effect: In this study, the term effect referred to a change in a participant's academic performance or attitude when one used a scratch program or PowerPoint presentation to learn acid-base reactions. What happens when the virtual laboratory method is used in teaching acid-base reaction, would the result improve, remain static or decline? It's the influence that the scratch program/ PowerPoint Presentation method would have on the academic and attitude of the learners. The effect of either scratch or PowerPoint presentation would be measured using the pre-test and post-test on academic performance, whilst the Likert scale and the interviews would measure the change in attitude of the learners. In the post-test, the scores of the learners were different because of the intervention that the different groups were given.

Virtual laboratory: this study, referred to the scratch program that was created by the researcher and the PowerPoint program that was used in the study. Users can design, develop and achieve pre-determined experiments that simulate experiences and processes in real-world contexts. A virtual laboratory is an on-screen simulator or calculator that helps test ideas and observe results. It enables learners to connect to a site so that learners can acquire the necessary knowledge and skills from the gadgets.

Virtual learning: This is the process of using technology to deliver educational equipment. It is an experience of learning supported by electronic devices both inside and outside the resources of an educational institution as it takes different forms and it relies heavily on modern e-learning tools that keep learners engaged. The learners and teachers are physically separated, and they mostly interact in an online environment. Therefore, virtual learning is carried out in a virtual setup using electronic study content developed for live web-based conferencing or self-paced online tutoring and teaching. In this kind of learning, the communication between the learners and their instructor is done through video conferences, forums, and instant messages.

Upgraded Secondary Schools: These are schools that were upgraded from primary schools to secondary schools running from pre-school to grade twelve mostly using the same buildings such that they were also referred to as combined schools. These were initially built and operated as primary schools but were later given secondary school status, more especially between the periods 2012 to 2021. Mostly these schools were run by one head teacher with two deputy head teachers. However, the government abolished combined schools and separated them into either primary schools or secondary schools with two different administrative structures where the primary section is run by one head teacher and the secondary section by another head teacher though the learners still use the same classrooms differentiated by time shifts.

Acid-base reactions: These are a chemical reaction that involves the exchange of one or more hydrogen ions H+ between species that may be neutral(molecules, such as water, H_2O) or electrically charged(ions such as ammonium NH_4^+, hydroxide, OH^-, carbonate CO_3^{2-}). An acid-based chemical reaction is a chemical reaction that occurs between an acid and a base. These would be tested using the litmus papers and the indicator would use the neutralisation.

PowerPoint presentation: This is a program developed by Microsoft comprising slides that may have text, images, and other media such as audio clips and movies. It is a word processing software, outlining, drawing, graphing, and presentation management tools (www.youth4work.com). However, when visualisation is included, it refers to educational materials directed at both the sense of hearing and also the sense of sight, as audio clips and video clips are included. The method is an instruction where particular attention is paid to the audio and visual presentation of the material where the class becomes more interactive and interesting, hence it focuses on a student-centred approach. The lesson content would be installed on each computer that the learners would be using. As the learners are balancing the equations, they would follow the audio and video on how to balance the chemical equations and then try to balance them in their books.

Academic Performance: The learner's ability to meet the expected learning outcomes by demonstrating a good understanding of concepts in acid-base reactions. The demonstration of knowledge and skills in a specific context which can be assessed through pre and post-tests. When learners write a test and they score high that means their academic performance in that regard is high too. This is measured by having both a pre-test and a post-test. A change in performance at post-test is always attributed to an intervention given to a particular group. This means succeeding in correctly reaching the endpoint or equilibrium in acid-base reactions by noticing the colour change. This also includes the processes the learners would undertake to be able to correctly reach the endpoint of the acid-base chemical reaction. This would be measured by the written exercises and test results a learner would get when the practical is correctly using the virtual laboratory. The learners would be taught either the virtual laboratory or the traditional methods of how to reach the end point of acid-base reactions using the virtual laboratory. Therefore, if the learners follow practical procedures, for reaching the end point of the acid-base reactions and correctly making calculations a learner would be considered as achieving the objective of reaching the end point of acid-base reactions and proper calculations. This would be measured by the following steps on how to correctly reach the endpoint and also make effective calculations. The learner who follows the steps correctly in reaching the endpoint and making good calculations would be considered as one who has attained the objective of having academically achieved the intended lesson attainment.

Attitudes towards acid-base reactions: This is the behaviour a learner exhibits towards acid-base reactions. This is the way learners would be acting towards learning acid-base reactions. Attitude towards learning acid-base reactions is important as it determines whether a learner would be able to determine a correct equilibrium as a positive help to bring optimism in succeeding in determining the endpoint of the acid-base reaction. Therefore, learners with a good attitude towards learning acid-base reactions would easily follow the necessary processes to reach the end point of the acid-base reaction, as compared to learners with a poor attitude. This would be measured by observing the learners' expressions, such as the rate of tackling both group and individual tasks on acid-base reactions using the virtual laboratory. The learners who would be first to reach the computer and the activities would be taken as having a good attitude towards learning about acid-base reactions using the virtual laboratory, whilst those who have to be reminded several times to go and perform an activity would be considered to be having a negative attitude towards learning acid-base reactions using the virtual laboratory. For those learners who would be taken to have a positive attitude, a further indication would be whether they are correctly using the virtual laboratory apparatus or not using the results from exercises and tests written during the research period.

Meaningful learning: The full understanding of the concepts by relating each of the concepts by an active procession of prior knowledge to the new knowledge. The active building process by the learners in acid-base reaction concepts using their mental effort in coding the concepts in the scratch program. The learners are active participants when conducting scratch programs as they interact among themselves and also with the scratch program software leading to a high retention rate. As a result, there is an effective commitment for effective learning to take place. Meaningful learning was measured using the Likert scale which assessed the attitude of the learners including the observations and the tests conducted. The learners tend to have experience in using digital gadgets where they learn scientific skills which when developed would yield meaningful learning among the learners.

Learners' Attitude to acid-base reaction: In this study, referred to their feelings about the use of a virtual laboratory on acid-base reactions, as measured on the Attitude scale. The Likert scale was used to determine the attitude of the learners at pre-test and post-test. The learners would tick their responses from strongly agree to strongly disagree. Thereafter, their responses would be analysed using the Mann-Whitney U test. At post-test, the learners' attitudes would be different because of the different interventions that the learners had undergone.

Learner performance: In this study, it referred to the test scores the learners obtained in academic performance tests. It was tested using the Pre and Post-test. A learner is considered to have performed well when his or her test scores are higher. At pre-test, it determined the level of academic performance of the learners before learners were given an intervention. However, in post-test, the academic performance was different among learners because of the difference in the type of intervention given to each group.

Coding: In this study, it refers to the process of combining "my blocks" and sprites in the scratch program when the titration experiment was being created. The various images of the titration experiment were downloaded and placed in the scratch program platform. The arrangement was done by manipulating “my blocks’ timings with the sprites including the insertion of the narration in the scratch program. This was measured by the learners’ abilities to create the scratch program of titration. The learners were showcasing their created scratch program to their fellow learners during the intervention stage. This was the practical aspect in which the learners were supposed to combine the theoretical knowledge with the practical aspect using the scratch program.

1.11 The Scope of the Study

This study will look at the performance of learners in acid-base reactions using the titration experiment created from scratch program. A titration experiment is one of the tests done under neutralisation where an acid and a base react to form salt and water only. The study looks at the effect the titration experiment created from scratch as one of the virtual laboratory tools would have on the academic performance and attitude of the learners. The learners would learn how to calculate the concentration of the acid using titration experiments. It’s the positive change in the learners that would enable the learners to improve academically hence bringing the use of digital gadgets to the learners so that its effect can be tested at both pre-intervention and post-intervention.

1.12 Ethical Considerations

The researcher first sought ethical clearance from the University of Zambia Humanities and Social Sciences Ethical Committee(HSSREC No. 00006464) to proceed with data collection. Ethical issues were carefully considered for this study. Before data collection, the researcher asked for permission from the District Education Board Secretary to access upgraded secondary schools where the research was to be conducted. The study avoided the disruption of the School's normal programme by maintaining intact classes and meeting research participants after normal classes were over. Participants were informed of the purpose and significance of the study and that they had the right to withdraw at any time. Confidentiality and anonymity to participants were guaranteed by asking research participants not to write their names or initials on the instruments that were administered. All participants were referred to by pseudonyms or code names. The data that was collected was reported honestly without changing the findings and when the study was done, the research findings were made available to both research participants and the School authorities. Finally, during laboratory activities, precautionary measures were taken to avoid accidents in the laboratory.

At the end of the intervention, the learners were taught the different interventions that they didn't learn during the intervention phase.

1.13 Chapter Summary

This chapter has presented the background to the study and outlined the case of the study. The chapter has also identified the problem of the study, purpose and significance of the study, research objectives, research questions, operational definition of terms, the scope of the study and lastly ethical considerations. The next chapter looks at the literature review.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews existing and related literature on virtual laboratories and how it informs the study of virtual laboratory. It discusses some studies carried out in other countries as reported by different researchers and authors and finally focuses on the Zambian situation.

2.2 The Origin of Virtual Laboratory

The first virtual laboratory was invented in 1977, and it was titled Virtual Laboratory of physiology whose main focus was to provide technological preconditions for physiological research in the 19th Century. As a result, relevant texts and images were created as a database.

The early stages of virtual laboratories saw the development of software and platforms to replicate laboratory experiments in digital environments. These initiatives focused on creating interactive simulations and activities that could provide learners with a close approximation of real laboratory experiences (Anderson & Liarokapis, 2007).

The virtual laboratory in chemistry education has been a debated part of the curriculum since its beginning in the late 1800s to the early 1900s. However, empirical evidence for the validity and importance of laboratory education was lacking from around the 1970s to the 1980s (Rowe, 1978; Hofstein & Lunetta, 2004). Even recently, the virtual laboratory's usefulness is an issue still being debated, though many science educators advocate for the importance of virtual laboratory inclusion in chemistry lessons (Hawkes, 2004; Morton, 2005 & Stephens, 2005). With the advent of diseases such as the coronavirus of 2019 (COVID-19), virtual laboratories seem to be a vehicle for learning science practically. However, conventional laboratories are more convenient because there is physical interaction between the learners.

Furthermore, the recent developments in educational delivery, particularly in the area of technology, have led to questions regarding how the best chemistry education instruction can be designed (Dori, & Belcher, 2005). The facilities that offer distance and online education delivery at both the high school and tertiary levels have new ways to teach and deliver content to their learners, particularly using modern technological equipment. As a result, this has led some to consider computer simulations as viable options for laboratory activities. The utilisation of virtual laboratories to enhance or even replace certain physical laboratory activities is not new, and many laboratories use computers at many different levels to both analyse and even create databases (Belcher & Dori, 2005).

However, there has been scepticism regarding the use of these virtual laboratory tools as a replacement for hands-on laboratory experience. Arguably, therefore, both the American Chemical Society and the College Board have decided to endorse hands-on laboratory activities as preferred over the virtual laboratories for chemistry majors at the college level and for high school Advanced Placement classes respectively (Dillon, 2006). The argument is that hands-on are real experiments that bring about reality in class hence high levels of retention. This would enable learners to acquire necessary skills and knowledge on how laboratory activities are done and safety in the physical laboratories which is not granted in the virtual laboratory. Any attempt to compare hands-on laboratories and virtual laboratories is stymied due to the lack of sufficient research in the area of virtual or computer-simulated laboratories as well as traditional hands-on laboratories (Hofstein & Lunetta, 2004; Ma & Nickerson, 2006).

Besides that, many of the research studies conducted so far looked at different purposes and different content, making it very difficult to deduce the overall effectiveness of simulations as a whole (Allen et al., 2004, Josephsen & Kristensen, 2006). Many simulations have also been created to deal with specific problems in laboratories and lectures, such as misconceptions and connections between the particulate, macroscopic, and symbolic worlds in the laboratory (Jones et al., 2008). Recent studies, using new computer simulations mainly as supplements, have shown some evidence that these laboratories can help increase lecture test scores, enhance students' attitudes, improve preparedness for hands-on laboratory, and strengthen conceptual knowledge (Allen et al., 2004; Allen et al., 2005; Liu, 2006 & Adlong et al., 2009). They have been studied as both pre-laboratory preparations and post-laboratory reviews (Allen et al., 2004; Burewicz & Miranowicz, 2006; Supasorn et al., 2008; Limniou et al., 2009). Since many of these virtual simulations are done in addition to the normal hands-on laboratories, these improvements may be mainly due to more time on task. A review of several studies using virtual laboratories in different science classes indicated that the results were varied regarding the efficacy of virtual laboratories. The lack of a consistent message when looking at virtual laboratories is difficult to achieve, at least in part because of the different goals that each research project focuses on (Ma & Nickerson, 2006). One of the outstanding primary concerns regarding virtual laboratories was their inability to teach laboratory techniques. However, one of many advantages of virtual laboratories appears to be the ability to help learners properly understand the concepts in chemistry by allowing students to visualize the particulate nature of chemistry.

A study of interest in the development of virtual laboratories was done by Liu (2001) which was tailored specifically to high school learners in the greater Washington metropolitan, where holiday lectures were offered from December 1993 by the Howard Hughes Medical Institute. The title of the study was the development and evaluation of virtual laboratories and other interactive learning tools. To make virtual laboratories a resource for science education, a variety of features and other components were added to achieve audience expectations as much as possible. This improved the attention of the learners such that the academic performance also improved.

At present, this holiday lecture program has a variety of educational components that are available on the website designed to hold the content. One of the additions made to the lectures was animation. Animations are very useful for revealing hidden worlds, clarifying anatomical relations or showing complex processes such as molecular interactions. Animations play a crucial role in science education by making complex concepts visually accessible, enhancing engagement and facilitating understanding of dynamic processes, particularly when illustrating abstract ideas or changes over time, which can significantly improve pupils’ learning and retention compared to traditional text based methods.

Furthermore, click and learn is the name used for the web-based interactive demonstration which is a notch beyond animations on the inquiry-interactive scale. These are excellent lecture enhancers. These are useful for making graphs or illustrations interactive and for helping the learner make complex comparisons, which can include illustrations and animations.

Among the lecture enhancers such as animations and click and learn, virtual laboratories were observed as the most interactive products and potentially high on the inquiry scale as they provide a very satisfying experience for individual learners. These are used in a more formal setting as supplemental materials to prepare for or reinforce a wet laboratory or even to provide a laboratory-like experience when a wet laboratory is not possible. Therefore, virtual laboratories are useful for revealing science as a process and for carrying a learner through that process, while, treating concepts and methods, including technology hand in hand, virtual laboratories can be made complex like real experimentation and, of course, remediation can be programmed.

This study is relevant to the current research as it evaluated the use of virtual laboratories which are being used in the current study. The upgraded secondary schools lack adequate laboratory apparatus and equipment. Hence, they would be useful in the execution of science lessons in these schools. Therefore, its development and evaluation would enable the researcher to focus on the interactive part as an enhancement in the learning process.

However, the study was purely quantitative, where it just focused on academic performance without looking at the qualitative aspect where the attitude of the learners would be established. It's against this background that the current study utilises both qualitative and quantitative methods for the study to explicitly look at attitudes and academic performance.

Therefore, there was a great need to look at the nature of virtual laboratories which made them improve learners' attitudes and academic performance. As a result, the next section looks at the virtual laboratories and their nature.

2.3 Virtual Laboratories and their Nature

A virtual laboratory is on a virtual platform with a similar interface and functions to a real physical laboratory. It's a computer-based activity where students interact with an experimental apparatus or other activity via a computer interface. Furthermore, a virtual laboratory can also be described as a computer-accessible laboratory which may be simulated by running a software package or which may involve real remote experimentation. An interactive environment for creating and conducting simulated experiments where the real world is reproduced within the computer (Ma & Nickerson, 2006).

Virtual laboratories are one of the many digital tools that can be used to provide distance and online learning for laboratory sessions. These virtual laboratories are computer-based-simulated learning environments that can range from simple 2D visualisations of laboratory experiments to advanced 3D simulations that try to replicate real laboratory environments (Jones, 2018). With recent virtual reality (VR) technology, it is even possible to be fully immersed in the virtual laboratory environment performing realistic laboratory handling. Some benefits that virtual laboratories can offer, compared to traditional hands-on laboratories, are: reduced cost, greater accessibility, time-saving, safe environments, and flexibility in self-regulated learning. However, depending on how the virtual lab is used, the absence of other students or tutors, and the lack of the real-life feel of a laboratory may present drawbacks to these virtual applications (Jones, 2018).

Different results are found when virtual chemical laboratories are compared with traditional hands-on laboratories. These comparative studies suggest that virtual chemical laboratories are equally effective or sometimes better than hands-on laboratories regarding declarative knowledge, procedural knowledge and skill-based outcomes. These findings align with outcomes of other literature reviews in which also equal, or improved results were observed between non-traditional (for example, virtual, remote and at-home kit) and traditional laboratories (Hensen, Glinowiecka & Barbera, 2020) While it is frequently argued that virtual laboratories cannot replace real hands-on laboratories very little evidence has been found that virtual laboratories perform worse than hands-on laboratories. This means that learners do learn procedural knowledge and laboratory skills in virtual environments where physical interaction is limited. Especially when procedural guidance was provided during the virtual experiment, learners were able to perform better than their peers who were trained in the real laboratory.

However, it is also argued that possibly the laboratory practical experiments were so easy that simple interactions in virtual laboratories are sufficient to learn the techniques (Hensen, Glinowiecka & Barbera, 2020). More research is required to investigate practical laboratory skills in virtual laboratories as there is a lack of studies that assess skill-based learning outcomes. So, while the media comparison of virtual and real laboratories steers towards equal effectiveness, virtual laboratories still have the advantage that no physical laboratory environment is needed, thus reducing cost, time, and staff personnel and allowing easy accessibility. Furthermore, a more effective use of virtual laboratories is to utilize them as a supplementary tool combined with hands-on laboratory laboratories, resulting in improved cognitive and skill-based outcomes. When virtual laboratories are provided as pre-laboratory exercises, the self-efficacy of students is significantly improved compared to hands-on laboratory activities only. However, one must be careful not to overwhelm learners with extra workload or demotivate them with post-laboratory exercises.

Non-coherent results are found when the attitude and usability of virtual laboratories towards practical chemistry are compared. Some studies involving virtual laboratories showed no difference in learners' attitudes, while other studies observed worse results when compared to hands-on laboratories. Some learners seem to believe that conventional laboratories are more useful and easier to use than virtual laboratories. The reasons for these findings are still unclear, but some authors suggest that it could be due to self-selection bias or instructor effect (Herraez, 2022).

Chemistry is perceived by most learners as a challenging science subject since it is difficult to construct the abstract concepts frequently encountered in the subject area (Ayas & Demirbas, 1997). Although Turkish students study chemistry as a minor part of the primary school science course, it is first encountered as a separate course during ninth grade. More than seventy percent of these learners took the course for the first and last time (Ayas & Demirbas, 1997). Therefore, achievement in the chemistry course during this period profoundly influences learners' branch preferences in their subsequent education. Previous studies of ninth-grade chemistry topics found that learners can understand the course unit on physical and chemical changes (Ayas & Demirbas, 1997), but have difficulty understanding events at the micro level and explaining chemical changes about chemical bonds (Adik & Kabapinar, 2005). In addition, the literature shows that learners have difficulty in constructing the topic of the chemical changes unit in their minds; and that teachers do not support students adequately during this construction process (Palmer & Treagust, 1996; Ayas & Demirbas, 1997; Ayas, Karamustafaoglu, Sevim & Karamustafaoglu, 2002; Kabapinar & Adik, 2005; Ozmen, 2005; Atasoy, Genc, Kadayifci, & Akkus, 2007). The reason for this weakness is frequently attributed to the lack of laboratory practice (Yang & Heh, 2007). Although laboratory work is an indispensable element of understanding chemistry courses, previous studies have reported that it cannot be properly embedded into traditional chemistry courses for various reasons, such as safety concerns, a lack of self-confidence, and an excessive amount of time and effort required to conduct accurate experiments (Elton, 1983; Bryant & Edmunt, 1987; Hofstein & Lunetta, 2004; Durmus & Bayraktar, 2010). Nonetheless, it is not impossible to overcome these obstacles via technology-based alternatives (Okon, et al., 2006).

Herraez (2022) presents some guidance that may help in choosing, designing and particularly implementing practices around virtual laboratories and other simulations of experimental environments and techniques. The main aim was to provide more active and significant learning by engaging students in the process, to support and facilitate the practical sessions and, in cases where real experiments are not feasible, to provide some alternative exposure of the students to the laboratory work. The findings of the study show that learners were able to assess themselves automatically as the virtual laboratories were going. This brought about a lot of motivation on the part of the learners to continue practicing as they had feedback. This increased their interest in learning because of motivation (Tuysuz, 2010).

This study is in line with the current study as it looks at scratch projects as both a supplementary to the physical laboratories and where these are not available, it becomes an alternative to the physical laboratories in the learning process. Learners are engaged in the learning process, they master the concepts as they are in charge of their learning process. They become more responsible for their learning process such that acquisition of skills and knowledge is enhanced. In this case, the teacher becomes more of a facilitator as compared to the oasis of knowledge. As a result, virtual laboratories promote learner centred approaches.

On the other hand, a study by Tuysuz (2010) reviews that a virtual laboratory related to separation of matter was used to review Grade 9 learners where it was prepared thereafter, instituted to determine its effect on the learners' academic performance and attitude. The title of the study was the effect of the Virtual Laboratory on students' achievement and attitude. In chemistry education, laboratory activities increase learners' interest in the subject matters covered in the class and help their learning of scientific concepts (Herraez, 2022 & Alexious, 2005). This was a quantitative study where virtual experiments were prepared using a flash program and used in the experimental group.

The study is relevant because it used the Flash program as a virtual laboratory to teach separation techniques. The current study, however, uses a scratch program equally to teach titration as a component in the acid-base reactions. This study by Tuysuz (2010), used only tests just on pre-intervention and post-intervention without looking at the other data collection instruments. However, the researcher in the current study uses many data collection instruments so that the findings can be accepted as a convergence approach is used to make conclusions between qualitative data and quantitative data.

The paper by Alexious (2005) proposes and describes an educational virtual laboratory that aims to meet the requirements of a real laboratory that supports communication and collaboration. This was based on experience in which the practical component of the educational process is very important. However, the time and financial resources often required for the setting up and construction of scientific laboratories are outside the scope of many institutions (Alexious, 2005 & Tuysuz, 2010). Therefore, a solution to this problem could be found in the adaptation of virtual reality technology. The main goal of an educational virtual laboratory is to provide all the simulations, tools, applications and conditions necessary, which would consist of an efficient space where experimentation, communication and collaboration can be used for the maintenance and exchange of rich knowledge. The paper concludes that as the internet is turning into a truly multiservice network with a steady increase in bandwidth and decrease in response time, the environment becomes more suitable for the implementation of e-learning such as virtual laboratories.

One study that highlighted the use of virtual laboratory simulation too was by Burke, Greenbowe and Windschitl, (1999). The study was done to understand the misconceptions students had when learning electrochemistry. Burke, Greenbowe and Windschitl (1999) developed innovative teaching strategies and resources for electrochemistry which aimed at enhancing student understanding and engagement. In this study, simple animations were created to help students understand and view the particulate aspect of chemistry and its implications for electrochemistry. The simulations were used in lectures to visualise the particulate view of the matter and the students' performance became better. In this quantitative study, it was revealed that the learners who used a virtual laboratory had no misconceptions about the terminologies used in electrochemistry. As animations are made, they are tailored to a particular acquisition of concepts.

Therefore, this virtual laboratory was tailored to remove the misconceptions that the learners possessed. Connected to this study in the sense that a scratch project was made to enhance the acquisition of knowledge and skills in performing acid-base reaction experiments. This topic has been a challenge to most learners, hence the creation of a scratch project would assist in enforcing knowledge and skills in the learners to perform the titration experiment. The only difference is that the current study enhances animation with audio whereas the study under review had no audio to enhance its usability.

Alexander et al, (2017) reports findings from a pilot study on learners' attitudes, motivation and self-efficacy when using the virtual laboratory program. The title of the study was Virtual Laboratories in science education: students' motivation and experiences in Two Tertiary Biology Courses. This was a mixed study where tests and observations were used to collect both quantitative and qualitative data gathered. Motivation and attitude towards the virtual exercises were evaluated. Teachers observed that learners were able to participate in discussions at a higher order thinking level than in previous years when the programme was not used. The study concludes that virtual laboratories have the potential to improve learners' pre-laboratory preparation. Indeed, virtual laboratories enable learners to be focused and manipulate variables to predict or infer a particular phenomenon. Therefore, the inclusion of virtual laboratories in the learning process is good as learners would be wholly involved in the learning process by acquiring necessary scientific skills and knowledge. This study is in line with the current study because the learners are engaged in the learning process. In fact, Burke, Greenbowe and Windschitl (1999) supports that virtual laboratories improves learner understanding and engagement which in turn improves learners' academic performance.

On the other hand, Spernjak and Surgo (2018) reports on the contribution to biological knowledge of three different laboratory technologies and also endeavours to discover which technology learners would prefer most. Each laboratory variant was prepared in a triplet as classical laboratory and an interactive virtual simulation. The title of this research was differences in acquired knowledge and attitudes achieved through traditional, computer-supported and virtual biology laboratory exercises. This was quantitative research performed on six hundred and seventy learners at a school for all genders, aged between 11 and 15, of lower secondary Slovenia schools performed where three well known and easy to perform laboratory exercises were done in which included gas exchange, activity on yeast and heart rate as a motivational, computer supported laboratory and computer simulations. The findings indicated that there was no statistical differences pertaining to student's knowledge gain between these laboratory technologies with regard to grade, gender or school score. In this study, students preferred a computer supported laboratory mostly followed by a classical laboratory with a computer simulation in last place, regardless of student's grade, gender or academic scores. The learners performed better when the physical laboratories were used as compared to virtual laboratories because of the limitations in the virtual laboratories' usage and applications. This was in contrast to studies done by Kaulu (2011), Burke, Greenbowe and Windschitl (1999), and Alexandar et al (2017) whose studies supported virtual laboratories as a proper way to improve learner academic performance. There are concepts in chemistry like chemical reactions which can be best understood when animations are used. Therefore, when virtual laboratories are used and applied correctly, they enhance academic performance and attitudes among the learners. In this regard, virtual laboratories could be used as supplement to physical laboratories.

Additionally, Flan, Garcia, and Serrano, (2023) looked at traditional laboratory experiments having been at the centre and a distinctive role in science education. The title of the study was traditional vs virtual laboratories. The main aim of the study was to analyse the impact of the use of both traditional and virtual laboratories on basic science subjects in healthy science education. The learners who were a part in the study carried out laboratory experiments both traditionally and virtually and completed a questionnaire to assess their satisfaction and the impact of both approaches at the end of the course. The results point a statistically significant differences in favour of traditional laboratories in all the studied variables. This study supported Spernjak and Surgo (2018) where the findings showed that there were significant statistical differences in favour of traditional laboratories in all the available variables. The students exhibited positive attitudes toward traditional experiments. These results emphasise the importance of carrying out hands-on experiments to boost student motivation and perceived performance. Even when virtual laboratories are used, learners need to be wholly involved in the learning process such that they create their virtual laboratories. The only problem that was discovered was that the teachers had limited abilities in creating virtual laboratories. These could be used in the learning process to improve both the academic and attitude of the learners. As a result, meaningful learning would be enhanced and the learners would be able to fully participate so that concepts are acquired.

The study by Matovu, Matiye and Ungu (2003) looked at studies published between 2016 and 2020 to understand how science educators designed, implemented and evaluated Immerse Virtual Reality (IVR) based learning. Educators commonly adopt IVR to better aid the visualisation of abstract concepts and enhance the learning experience. The title of the study was immersive virtual reality for science learning: design, implementation and evaluation. This was purely a qualitative study where document analysis was used in the collection of data. Participants generally reported that their Immerse Virtual Reality (IVR) experiences as positive on engagement and motivation, but the learning outcomes were mixed. Mostly, the learning theories did not appear to play a strong role in the design, implementation and evaluation of IVR-based learning. Careful consideration of the immersed design features in alignment with the rationales for adopting IVR and evaluation methods may contribute to more productive investigations of the educational benefits of IVR to improve science teaching and learning. This study failed to categorically state the reasons that made the outcomes mixed as those for and against the virtual laboratories' use in the learning process. However, the study concludes that there are educational benefits of IVR which, when harnessed, would bring about improved learner outcomes (Alexandar et al, 2017, Spernjak & Surgo, 2018, Andrew, Leung and Nicolas, 2022).

Besides, Andrew, Leung, and Nicolas (2022) wrote a study that investigated virtual chemistry laboratory modules that were investigated as a potential learning resource that complements traditional in person experiments. The title of his study was exploring the viability and role of virtual laboratories in chemistry education using two original modules. In this study, two interactive modules which were the rate of reaction and modules of organic molecules were created. Learners used the two modules to reinforce their knowledge of specific chemistry concepts and prepare themselves for the corresponding laboratory experiments. The findings from the academic performance suggest that independent learning had an overall positive impact on learning when used in conjunction with traditional methods. In line with independent learning, even this study in the virtual laboratory on learning acid-base reactions would be more applicable as the scratch project animations would be used in and outside classroom practice. As learners are playing with digital gadgets, they would be playing with scratch animations, which in turn would improve the academic performance of the learners.

Furthermore, Liminous, Roberts and Papadopaulos, (2008) studied how virtual reality environments could raise students' interest and motivation for learning. The title of the research was to fully immerse the virtual environment in Chemistry education. By using the chemical animations, it could visualise the chemical phenomena easily and quickly without knowing any special computer language and export the application to files which were compatible with CAVE (object or open GL files). After the participation in 3D animations at CAVE, learners comprehend the molecules' structure and their changes during a chemical reaction are more real than during the 2D animations on the computer desktop, as the limitations of human vision have been overcome (Greenbowe, 1994). The learners were enthusiastic as they had a feeling that they were inside the chemical reactions, and they were facing the 3D molecules as if they real objects in front of them. The essence of virtual laboratories is to create software for a scientific phenomenon. This improves both attitude and academic performance of the learners

One of the related study to the current research was by Erni, Jimmy and Roza (2019) which was conducted to figure out the use of virtual laboratories on student's conceptual understanding of acid-base titration. The title of the study was," the use of virtual laboratory to improve student's conceptual understanding in acid base titration subject. This study was an experimental research which used one group pre-test-post-test design which was treated with a virtual laboratory. The data was analysed using a T-test and it was concluded that there was significant differences between scores of the pre-test and post-test. Therefore, Eli and Widiyanti (2020) supports that there was an increase of conceptual understanding of acid-base reactions when virtual laboratories were used.

This study was relevant to the current study as it used acid-base titration which was the one which the current study used. The concepts helped to shape the conceptual understanding of the acid base titration which was based on scratch program. The project was created using the concepts which were gotten from the study by Erni (2024).

However, the study by Erni, Jimmy and Roza (2019) used one group pre-test –post-test as an experimental design whilst the current study used Solomon four experimental group design. Despite both designs comparing the pre-test and post test scores, the Solomon four compares pre-test of the two groups and also compares the post-test of the four groups. As a result, it gives the clear picture of which intervention is good compared to the other.

Furthermore, the current study is a mixed approach where it used both qualitative and quantitative approach to research, the study by Erni (2024) was purely a quantitative approach. As a result, the researcher was able to explicitly collect information on why a particular group was able to perform well academically as compared to another group.

Additionally, Eli and Widiyant, (2020) did a study where they also investigated how much animation assisted learning can improve high school learners' learning outcomes in chemistry subjects especially in acid-base solutions. The title of this study was the virtual laboratory of acid-base material to improve learning outcomes. The study was purely an action research which was classroom based conducted under four stages namely plannining, implementation, observation and reflection. Thirty-three learners were sampled. The study used pre-test, post-test, questionnaires and observations to collect data. When the data was analysed, it was reviewed that the learners had improved in their learning outcomes when animations were used.

The study by Eli and Widiyanti (2020) is relevant to the current study because it was based on acid-base reaction which the current study is also looking at (Erni, Jimmy & Roza, 2019). The learners have not performing well in this subtopic of acid-base reactions hence the need to find ways which would enable the learners to understand the topic better.

However, Eli and Widiyanti (2020) study differs with Erni, Jimmy and Roza (2019)'s study in the methodology. The earlier study used only the pre-test to determine the academic performance of the learners whilst the later one by Eli and Widiyanti (2020) used pre-post test, questionnaires and observation. Both earlier studies differ in methodology with the current study as interviews were included to exactly inquire on the attitude of the learners which the earlier studies didn't take into account. The current study looks at attitude as a fundamental feature to take into account when looking at the academic performance of the learners.

One of the reasons which has made the learners to fail to perform well in science based subject is the poor attitude which they exhibit. Therefore, there was a great need to find a teaching approach which would make the learners to have an improved attitude which would in turn improve the academic performance of the learners. This brought about the scratch program as part of the virtual laboratory which would make the learners to improve both their attitude and academic performance.

Another study was by Kallies and Sypasas, (2012) which reviewed virtual laboratory applications in a variety of educational settings in Biology, Biotechnology and chemistry. In order to run hands on activities, a teacher needs space, equipment and staff. Therefore, virtual laboratories can help to reduce the total cost and still complement physical presence. The title of the study was virtual laboratories in biology, biotechnology and chemistry education. The study was a quantitative study whose findings demonstrated that when virtual laboratories are used in a class, they have an overall positive effect on learners' cognitive load, skills development and motivation. The learners become more interested in learning scientific courses as compared to traditional teaching. This research work helps to respond to the first research question which looks at the attitude of the learners being established when a scratch project is used. As the learners become motivated, they in turn become more interested in the learning of scientific processes as virtual laboratories are being used. However, further review of this work showed that virtual laboratories should not substitute physical ones and that the advantages of virtual laboratories are better realised when combined with traditional Hands on activities. In this regard, the current study supports that virtual laboratories should be used as a supplement to physical laboratories.

Furthermore, a study by Ayas and Tatli (2013) explains that laboratory applications have generally been neglected in recent educational environments for a variety of reasons, such as lack of laboratory equipment, apparatus and chemical reagents. In order to address this gap, the study by Ayas and Tatli (2013) examined the effects of a virtual chemical laboratory on learners' performance among ninety (90) learners from three different 9th grade classes (an experimental group and two control groups). Study data was gathered from the pre-and post-chemical changes unit performance test, laboratory equipment test and unstructured observations. The collected data was analysed using SPSS (version 16). Comparisons were made within and between groups. It was concluded that the developed virtual chemistry laboratory software is at least as effective as the real laboratory both in terms of students' performance in the unit and students 'ability to recognise laboratory equipment (Agostinho, 2009). This is important because the current study looks at the improvement of academic performance and attitude of the learners using virtual laboratories. This will make learners perform practical activities in science based subjects either as supplements to the physical laboratories or as a standalone virtual laboratory. As a result, the upgraded schools which lack laboratory apparatus would enable learners to acquire skills and knowledge through the consolidation of theory by practical skills.

This study by Lage, Platt, and Treglia, (2000) discusses the concept of "inverted classrooms" where traditional lecture content is delivered outside of class, allowing more time for interactive activities. This was a mixed study. The findings were that virtual laboratories are highlighted as an effective tool for engaging students in active learning experiences, including hands-on chemistry experiments. This study is in line with current research because it views virtual laboratories as enhancing the existence of knowledge as an integrated system in the cognitive structure. It enhances an ordered structure, which is hierarchical order. More Knowledge Other (MKO) as propounded by Vygotsky (1978) states that meaningful learning occurs when students learn from one another through interactions. This is brought about by having guided participation by either one's peers or someone more knowledgeable, such as teachers and lecturers. Even the current study is a mixed study which investigates the effect of virtual laboratories on both attitude and academic performance of the learners in acid-base reactions. The scratch program would allow students to have more time to be interacting with the learning materials by creating both animations accompanied by the narration.

Research by Agostinho (2009) explores the impact of computer-based practice, including virtual laboratories, on the learning of physical and cognitive tasks. It demonstrates that well-designed virtual laboratories can effectively enhance students' understanding of complex chemical concepts. It brings about meaningful learning as there is an affective commitment for effective learning to take place. Virtual laboratories make concepts be analysed, and the new knowledge is actively processed (Ayas and Tatili, 2013). Therefore, it enhances higher retention of scientific concepts. As virtual laboratories are being used, there is mental effort which is exhibited such that there is no reversibility of what is learned. It becomes part and parcel of the cognitive development of students.

The study by Kose, Erdogan and Ergin, (2010) investigated the effectiveness of a virtual chemistry laboratory environment on student learning outcomes. It suggests that virtual laboratories provide a conducive platform for conducting experiments and promoting conceptual understanding in chemistry. This was quantitative research which used pre-test and post-test. The findings of the study were that virtual laboratories were as effective at teaching scientific concepts as convectional laboratories. It could be used as a supplement to expensive laboratory work. Indeed, expensive and dangerous laboratory activities can be done virtually, which is less expensive and not dangerous. As a result, this brings in more conceptual understanding and retention of knowledge. It's against rote memory, which is easy to learn factual material or verbatim or to memorise, but at the end of the learning process it brings about poor retention of concepts and knowledge. This is relevant to the current study because the learners would learn titration concepts through laboratory work virtually. Besides, the virtual laboratory activities would be used to supplement those schools which had instruments in pre-laboratory activities. However, the major challenge was that the learners were not given a chance to state their attitudes towards the virtual laboratories, especially on the challenges they could have had with other teaching methods.

This research by Yuen (2011) focused on students' motivation and learning outcomes in virtual laboratories. It indicates that virtual chemistry laboratories can enhance students' motivation, engagement, and learning outcomes when compared to traditional methods. This was a mixed research method study which involved both qualitative and quantitative methods as an approach. When learners have a task to complete using virtual platforms, they would strive to complete it. Actually, it's in line with the expectancy theory by Victor vroom. According to expectancy theory by Victor Vroom, a person is influenced by the chances of completing the task and the likely consequences or the impact of completing the task. In this regard, a person chooses actions likely to give the students the reward. Therefore, when the students learn the concepts well in both theory and laboratory practical, they tend to conduct the same each time to achieve better results. This motivation is from the inside of the students, hence they would be motivated to conduct practical studies using the virtual laboratories. As the students' motivation is enhanced, the students would always conduct practical activities using virtual laboratories. This is as a result that more effort brings better performance, such that as the learners continue using virtual laboratories, they would perform as many laboratory activities as possible.

The study by Goksun and Bumen, (2012) examines the effectiveness of a virtual chemistry laboratory program in improving students' understanding of chemistry concepts. The study was quantitative where tests were offered, in both pre-intervention and post-intervention. Results of the study suggest that virtual laboratories contribute to better comprehension and knowledge retention. The virtual laboratories enable learners to cement what they learn theoretical to practical work. As they practice what they learn theoretically, learners tend to attain higher knowledge retention as concepts are well assimilated in the cognitive domain as compared to memorisation of concepts. Therefore, there is effective learning among learners as they can relate scientific ideas and concepts by making meaningful applications and analysis.

This study by Chaudhury and Kumar (2013) investigated the effectiveness of virtual laboratory experiments in helping students understand chemistry concepts. The title of the study was the effectiveness of virtual laboratories in understanding concepts in chemistry. The study was a mixed study where the researcher used both qualitative and quantitative methods and approaches to the study. It concludes that virtual laboratories can provide a safe and effective platform for experimentation and learning. This enables learners to become competent in performing more laboratory work as they criticize already existing scientific ideas. It makes learners able to solve problems using scientific processes. This study was relevant because the current study is also chemistry education based. Besides, it also uses mixed study approaches. However, it was not only using a topic but various topics in chemistry which made it less effective. It would have been better to research one topic then use it to study other topics.

Another study of interest to this current study is by Herlato et al(2023) who defined Virtual laboratory as a computer software that has the ability to perform mathematical modeling of computer equipment presented in the form of simulations. Virtual laboratory is not a substitute for real laboratory, but are used to complement and improve the weaknesses of real laboratory. This study aimed to determine the efect of virtual laboratory combination with demonstration methods on lower-secondary school students' scientifc literacy ability in a science course.

The design of this research was quasi-experimental. The sample in this study was 102 students (12-14 years old) in a lower-secondary school in the city of Yogyakarta, Indonesia, used as experiment 1 group 1 (n=34), experiment 2 group (n=34), and control group (n=34). The three groups (experiment 1, experiment 2, and control) were tested with pretest and posttest. Experiment 1 group used virtual laboratory combination with demonstration methods, experiment 2 group used only virtual laboratory, and the control group used only a demonstration method. Scientifc literacy ability was measured using multiple choice tests before and after treatment. Statistical tests on mixed methods ANOVA were used to determine how effective the use of virtual laboratory combination with demonstration methods was good in improving scientifc literacy ability.

The research result based tests of Within-Subjects Effects showed that there was a diference between the pretest-posttest scores of scientifc literacy ability (F=10.50; p The result of effect size (partial eta squared) shows that the experiment 1 group to increase scientifc literacy ability is 84.5%; experiment 2 group is 78.5%; control group is 74.3%. So, it can be concluded that experiment 1 group (virtual laboratory combination with demonstration methods) provides the most effective contribution to improving scientifc literacy ability when compared to experiment 2 group virtual laboratory only) and control group (demonstration methods only).

The study was relevant to the current research as it was done in order to supplement the practical aspect which the learners were needed to learn at home independendly. However, the difference was on the quasi experiement while the current study was using solomon four experimental design.

Another study was also by Kumar (2015) which reported on the development of virtual laboratories for virtualising web laboratory techniques and experiments with the aid of graphics favoured animations, mathematical simulations and remote triggered experimentation. Virtual laboratories are an Information and Communication Technology (ICT) based initiative that is becoming more prevalent in universities for improving classroom education. The title of the study was using virtual laboratories as interactive textbooks: studies on blended learning in biotechnology classrooms. This study was an analysis as introduced as a learning tool in a blended classroom scenario. This was a pedagogical survey which used workshops and online feedback which was carried out among six hundred (600) university level students and one hundred (100) remote users of various Indian universities. The various learning groups were compared on usage of blended learning approaches against a control group (traditional classroom methods) and an experimental group (teacher mediated virtual laboratories). The study indicated augmented academic performance among students in blended environments. The findings also indicated the usage of remotely triggered laboratories aided enhancing interactive based laboratory education enabling anytime-anywhere student participation scenario. This is relevant to the study because it advocates learning even after class time. This means that learners would be able to acquire scientific concepts and skills even by using digital platforms. The difference lies in the target learners whereas the earlier study targeted students from universities, whereas the current study looks at secondary school learners.

A study by Diwarkar, et al. (2015) reviewed the analysis of the effective role of virtual biotechnology in improving academic performance of students and supplementing classroom education. In this study, virtual laboratories are viewed as visual education tools that offer diverse analysis of experiments through different components, like graphics mediated animations, mathematically modelled simulations where user interactive simulations, remote triggered experiments and Information and Communication Technology (ICT) based education are utilised. As a result, virtual laboratories have become a novel platform that helps users to engage in their proactive learning process. The study tested the virtual laboratories' perceived usefulness, adaptability and ease of use in different user groups in science and engineering. Its focus was on the science based students and teachers across the various universities in India. A direct approach through organised workshops was used to collect feedback from 2014 to 2015.

The findings were that participants reported an improvement in their academic performance as compared to traditional classroom scenario. The participants also reported that the virtual laboratory materials provided were easy to understand, hence suggesting the better adaptability of ICT enabled techniques among different users. The analysis concluded that virtual laboratories are able to overcome the limitations seen in classroom based education such as equipment accessibility, location and other economic issues. The study is important to current studies as it analyses the use of virtual laboratories' use in improving academic performance of the learners. Besides, the current study also looks at learning which is continuous even at home when the learners have knocked off. This study reviews an analysis of overcoming the limitations of traditional classrooms such as distance, hence it sits well with this current study. However, this study was just on analysis but didn't create virtual laboratories where the learners could be used to make their own study materials. It relied on already made virtual laboratories for their studies.

One of the local studies was by Musukwa (2019) explaining the factors which affect the provision of quality science education in selected colleges of education in Kitwe district on the Copperbelt. The study was based on an assessment of the preparations lecturers undertake before teaching science education lessons, besides examining the teaching methods used in the teaching of science education. The study was a purely qualitative study which employed purposeful sampling to select the sample size. The findings revealed that most lecturers lacked adequate preparation before teaching. Therefore, the introduction of virtual laboratories would enable teachers to prepare lessons online and send them to students. The study revealed that most of the lecturers used teaching methods that alienated students from participating in lessons. Mostly the lecture methods which did not promote active and reflective learning was used. As a result, the introduction of virtual laboratories would enable students to promote active and reflective learning. The lessons taught to students lacked practical activities. Therefore, students would go into the field as well, where they would teach science concepts theoretically. As a result, the introduction of virtual laboratories would enable students as they become teachers to prepare for practical work. The virtual laboratory would enable learners to become critical thinkers.

This research is important because it is connected with research work where there are no science practical activities conducted, the virtual laboratory would be used. In upgraded secondary schools, the infrastructure is inadequate. Therefore, it would promote computer laboratories as science laboratories to perform virtual laboratory learning. The gap the research didn't work out was in the alternative when the practical work was not done. Therefore, the inclusion of practical work being used in the virtual laboratories is good for the learners as it promotes skills and knowledge.

Davenport (2018) explores a study which assisted secondary school learners to develop an understanding of chemistry that integrates conceptual knowledge with experimental and computational procedures needed to apply chemistry in authentic contexts. This study described Chemistry Virtual laboratory as a set of online chemistry activities that were developed using promising design principles from chemistry education and learning science research. The title of the study was whether and how authentic contexts using a Virtual Chemical laboratory support learning. The study was a quantitative study which employed pre-test and post-test to collect data from more than one thousand four hundred (1400) high school learners. The study's findings were that learners who used Chemistry Virtual laboratory activities demonstrated increased learning as evidenced by improved problem solving and inquiry over the course of the activities and by statistically significant improvements from pre-test to post-test. The study furthermore stipulated that through exploratory analysis, it tends to suggest that learners may learn most effectively from these materials when activities are used after initial exposure to the content and when the learners work individually rather than in pairs.

This paper is important to the current study as it uses a scratch project to teach titration experimental procedures including calculations to the learners. However, contrary to Davenport (2018)'s study, the current study looks at learners learning through group work then getting to individual work such that even if learners have to go to their homes, they, would continue learning as they have learned a lot from the group activities. During group studies, learners would be able to have social interaction, which in turn would make them be able to find answers using computers or any other gadgets. However, pairing work would limit the learners, as if one fails, it means another one would fail except with scaffolding from the teacher. The study proves that when a virtual laboratory is used to teach scientific concepts, it makes learners be motivated such that it improves both their attitude and academic performance.

A study done by Mwamba (2021) was on the Zambian secondary school science curriculum in the wake of E-learning: a perspective of teaching and learning materials. The study aimed at assessing the preparedness of Zambian secondary schools to support e-learning of science in the wake of the Coronavirus 2019 (COVID-19) restriction of physical contact. In this study, e-learning referred to the broad use of electronic media (internet, radio and television) encompassing other teaching and learning materials to achieve the science curriculum objectives of both teachers and learners. Findings of the study showed that the sampled school lacked the teaching and learning materials necessary for e-learning of science through the education broadcasting system and social media platforms (WhatsApp and Facebook). It was also revealed that the science curriculum is an inherent requirement for practical learning activities and its non-inclusion of e-learning made it difficult to support E-learning of science subjects. It was concluded from the findings of the study that the Zambian science curriculum did not support e-learning of science during the Covid-19 school recess. As a result, there is need to include a lot of technological and digital platforms for the learners to acquire skills and knowledge even when they are not physically being taught in class.

Another study was done by Mtanga et al. (2012) on Information and Communication Technology (ICT). The study was based on research that was conducted in seven high schools in Lusaka, Zambia on the utilisation of ICTs in education. Areas of Information and Communication Technology (ICT) usage that were investigated included the use of ICTs in learning activities by pupils, the integration of different ICTs by teachers into the various teaching activities, and the use of ICTs in the operations of schools to improve administrative efficiency. Among the major findings of the research were factors inhibiting full integration of ICTs in the teaching, learning and administrative processes. It was reviewed that some teachers were not able to use the digital platforms, hence they would not be able to translate their lessons. This study is relevant to the current study as the virtual laboratories would involve the learners using digital platforms. Hence, if the teachers lack the skills and knowledge in information and communication technology, it would mean a failure to utilise the virtual laboratories. As stated in Diwarkar et al. (2015), the limitation of this study too was its lack of using the learners to create their own platforms. The study was on the analysis of the factors which were hindering the administrators from using the digital gadgets which were available for the improvement of the academic performance of the learners.

Furthermore, the study by Kaulu (2011) explored the use of a computer software called ‘Physicsclassroom’s effectiveness at enhancing pupil performance and attitude in kinematics in Physics at Munali Boys High School. The ‘physicsclassroom’ computer software was used as a supplement to traditional learning methods. The study investigated the effectiveness of the ‘physicsclassroom’ computer software in the learning of kinematics in high school physics at Munali Boys high school. The study was a mixed method research which used pre- and post-test, attitude questionnaire, observation schedule, participant reports and an interview with Physics teachers. The study’s findings review significantly high performance of 10.5% in the post tests for the experimental group than the control group. All the pupils interviewed agreed that the ‘Physicsclassroom’ computer software would be used for kinematics and other topics in high school physics at Munali high school. Furthermore, pupils showed a positive attitude towards the ‘Physicsclassroom’ computer software learning approach. This research is very important to the current study as it uses computers to display virtual laboratories for the learning of the learners. It differs with the current study in that interviews with Kaulu (2011)’s study were asked to teachers whilst this current study, interviews were asked to the learners. At the same time, the current study doesn’t have participant reports.

These studies collectively highlight the positive impact of virtual laboratories on teaching and learning chemistry concepts. They emphasize improved engagement, motivation, and understanding of complex chemical phenomena. As technology continues to advance, virtual laboratories are likely to play an increasingly significant role in chemistry education.

Virtual laboratories are the most interactive products and potentially high on the inquiry scale. The feedback from hundreds of users indicates that the virtual laboratories provide a very satisfying experience for individual learners. The Virtual laboratories are also used in a more formal educational setting as supplemental equipment to prepare for or reinforce a wet laboratory, or even to provide a laboratory-like experience when a wet laboratory is not possible. Virtual laboratories are useful for revealing science as a process and for carrying a learner through that process while treating concepts and methods/technology hand in hand. Virtual laboratories can be made complex like real experimentation and of course remediation can be programmed. Some of the techniques which involves learner centred approach would include PowerPoint presentation, PhET Interactive Simulation and Scratch program. The following sections discusses the above starting with PowerPoint presentation, then PhET interactive simulation ending with Scratch program following the effectiveness on learner centredness. PowerPoint presentation is less interactive as compared to PhET interactive Simulation but Scratch is more interactive in terms of learner engagement. However, the next section looks at Teacher Based Demonstration Experiment method which is the least in terms of learner engagement.

2.4 Teacher Based Demonstration Experiment

This is a teaching stratages where a teacher shows students how to do something step by step while explaining each step. This is a teaching technique that utilises visual aids and hands on experience to help students to understand complex academic concepts. This method is particularly effective for teaching skills or procedures that require a visual or physical demonstration (Bwalya et al., 2024). In this method, the teacher demonstrates the procedures thereafter asks learners to follow the instructions.

Teacher based demonstration experiment has three principles which are active learning, experiential learning and constructivism. Teacher based demonstration makes the learners to have active participation in a lesson as they conduct experiments or observe demonstrations. Besides, learners learn by experiencing and feeling the phenomenon rather than just memorising abstract concepts. Lastly learners construct their knowledge from the information given to them in class. This method promotes the construction of new knowledge as an interactive and iteractive process, allowing learners to grasp the concept and apply it to different contexts.

This technique helps the teacher to introduce certain topics vividly and clearly to pupils so that pupils can on their own carry out the activity or illustrations (Muzumara, 2008). Science deals with observable phenomena, it is important that pupils see a demonstration from their teacher which enhances learning. A good teacher based demonstration experimental method has clearly defined aims and objectives for a particular lesson. The demonstration can be observed by every pupil and the class is involved at every stage. Another quality of demonstration method is that it uses simple apparatus whose operations can be understood by the pupils (Muzumara, 2008).

Additionally, the Teacher Based Demonstration Experiment needs to be presented in a logical order for the learners to easily understand the build up of the concepts. This also stimulates curiosity and enquiry in the learners as learners are allowed to observe real objects and events (Clark,2008). The demonstration method should easily be performed by the pupils themselves following the guidelines.

A study by Bwalya et al.(2024) using the three teaching strategies which were Teacher Based Demonstration Experiment, traditional teaching methods and Students Hands on Experiments. The title of the study was an analysis of conceptual understanding of solutions and titration among Rwandan Secondary school students. The traditional teaching method was where learners learnt acid-base reactions theorectically while the teacher based experiment was where the learners were able to observe and perform experiements. The hands on experiment was where the learners performed experiments and demonstrated to each other. This was a quantitative study where achievement tests were given. The findings reviewed that Traditional teaching methods made learners to answer lower blooms taxonomy level questions consisting of mostly knowledge and comprehension level questions. However, the learners taught using teacher based demonstration experiment were not able to answer questions which were analysis. But the learners taught acid base reactions taught using Hands on Experiments performed better.

This study is relevant to the current study in that one of the groups in the study is using a teacher based demonstration method. Mostly in these schools, there is a shortage of reagents and apparatus, hence mostly the teachers demonstrate the experiments to the learners and then scant demonstrations are done by the learners. However, hands on experiments are scarcely done because there is a demand of more reagents and apparatus.

However, the study by Bwalya et al. (2024) departs from the current study as it used the solomon three group design while the researcher here used the solomon four group design. The current study again compares virtual laboratories to an audio visual powerpoint presentation but because the group design is solomon four, the third group is given an intervention hence the use of the most common teaching method.

Another study on teacher demonstration is by Clinton (2019) which was aimed at investigating how students of senior high school academic performance and attitude can be employed through activity based approach on the concept of acids and bases. The title of the study was improving student's performance on the concept of acids and bases using the activity method. This study was an action research which used pre-post test research design was used. The instruments for the study were tests, observation, questionnaire and interviews. Data was analysed using descriptive statistics. The pre-intervention and post-intervention findings revealed remarkable improvement in the student's performance. The findings of this study indicated that practical activity improves student's performance and understanding of science concepts. Observation of students revealed that they were highly excited when taught using practical activities. The study recommended that teachers consider the use of activity method during instructional period more than the lecture method to sustain student's interest as well as improve their performance in science.

The study by Clinton (2019) is relevant to the current study in that the research instruments are exactly the same. For the current, observation and interview schedules were used to collect qualitative data while the Likert scale and the Pre-Post test were used to collect quantitative data. Above all, both studies promote laboratory activities in the learning of acid and base reactions. Laboratory acitivities assist the learners in cementing the theory which they learn. This assists the learners in acquiring the necessary practical skills which promotes long term retention of concepts.

However, the current study departs from the study by Clinton (2019) in that is pre-post test research design while the current study is based on Solomon Four Group design. Four groups were created where three groups were given an intervention while the other group group had no intervention. Two groups received the pre-test while the other two groups had no intervention. Another difference is that, the current study uses scratch program to teach acid base reactions while the previous study uses the demonstration methods in teaching acids and bases. Arda et al. (2005) supports that laboratory activities increase both students'academic performance and attitude though using the computer based methods.

Furthermore, another interesting study was by Arda et al. (2005) where traditional methods were compared with computer based methods. The title of the study was traditional and computer assisted learning in teaching acids and bases. The study looked at the influences of the three dimensional spatial visualisation abilities, computational attitudes and learning styles of the learners on their acquisition of knowledge were investigated. The study was a mixed study. The findings reviewed that the learners who were taught acid bases using computer aided methods developed better attitude and performed better in achievement tests compared to the learners who were taught acid bases using traditional means.

This study is relevant to the current study as traditional methods are being used in teaching learners through demonstrations. The use of computer aided methods in the study by Bwalya et al. (2024) also supports the use of scratch program and PowerPoint presentation used in this study as well. Besides, both studies are mixed studies investigating the attitude and achievement of the learners. Using digital platforms in teaching learners improve their attitude and academic performance as these gadgets

However, the current study despite having a computer aided teaching strategy, the learners were taught only visually but the current study uses both visual and audio learning modalities. Learners always learn better when their learning modalities are considered. The learners who learn better through audio would learn whilst those who would learn better through visual would have an improved attitude and academic performance. Therefore, the scratch program having all the learning modalities would improve the attitudes as well as academic performance of the learners.

Another study of interest was by Omwirhiren (2016) which investigated the effects of teacher's instructional methods in students' learning outcomes using two instructional methods which were demonstration and lecture methods. This was a quasi-experiemental group design target to senior secondary school chemistry learners using a Chemical Bonding Performance Test(CBPT). The test was analysed using T-Test and anova at alpha level 0.05. The findings from the study shows that there was significant difference in learning outcomes on students exposed to demonstration. Findings from this study suggest that chemistry teachers should incorporate demonstration method for teaching at senior secondary.

This research is relevant to the current study because it uses demonstration method which the current study uses in the form of Teacher Based Demonstration Experiment. It gives the current study a way of conducting demonstration when the apparatus and reagents are not enough but meaningful learning is suppose to be done. Besides, the study equally uses the pre-test and post test to measure the learners' retention of the learning outcomes which the current study also uses.

However, the study departs in terms of methodology where the current study uses solomon four group design where as the study under review used quasi-experimental design. The study under review analysed the data collected using t-test and anova whilst the current study used the non parametric test of Friedman's test and the Mann Whitney U test to analyse the results. The use of computer aided learning is nowadays supported hence the next section presents PowerPoint presentation as a digital platform to teach concepts in science.

2.5 PowerPoint Presentation Method

Microsoft PowerPoint, which launched officially on 22nd May 1990, is a proprietary commercial presentation program developed by Microsoft. Microsoft PowerPoint is installed and can run on any Microsoft Windows, including Apple's Mac OS X operating system (Ng & Komiya, 2000). Initially, PowerPoint was called Presenter when it was designed for the Macintosh computers by Dennis Austin and Thomas of Forethought, Inc.
The PowerPoint presentation can also be defined as an electronic presentation program that helps teachers to present lessons using a collection of slides. Therefore, a PowerPoint presentation is a collection of slides that can be used to create oral presentations (Ng & Komiya, 2000). The presentations consist of slides which may include text, images, and other media, such as audio clips and movies where learners could learn in the control group (Mason & Hlynka, 2004). However, sound effects and animated transitions can also be included to add extra appeal to presentations. Mostly, PowerPoint presentations are created from a template that includes a background colour or image, a standard font, and a choice of several slide layouts.

When presenting a PowerPoint presentation, the presenter may choose to have slides change at present intervals or may decide to control the flow manually. The flow of the presentation can be further customised by having slides loaded completely or one bullet at a time as displayed on a laptop or a projector. The slides vary such that some may contain texts, graphics, sound, and movies, which can be arranged accordingly. The PowerPoint presentation can be printed out, displayed to be viewed on a computer, or navigated through at the command of the presenter. A video projector display of slides can be used for large audiences. Mostly, webcasts are also formed from slides. There are three different movements provided by PowerPoint:-

1. Custom animations control the entrance, emphasis, and exit of elements on the slide itself.
2. The various movements between slides are called transitions.
3. Creation of animation pictures on small storyboards can be done using custom animations.

Several embedded PowerPoint features are flexible in presenting professional academic work. One of these features enables it not only to create a presentation that plays music throughout the presentation but can also include sound effects for specific slides. Above all, the PowerPoint presentation can be created in such a way that it runs in a movie manner. PowerPoint enables the teachers or the learners to create a slide show with narration and a laser pointer. The Microsoft PowerPoint application can also broadcast the presentation to specific users via a link and Windows Live. (Mason & Hlynka, 2004).

In the last twenty years, educators and researchers have begun to look carefully at science education and how students learn best. Dalton (1997) states that students learn better by being involved in the lesson (learning by doing). In the learning by doing a process, students are involved in "actively constructing knowledge concepts from a hands on experience, interpretation of results and enhanced teacher-peer interactions." Perkins, Loeblein, and Dessau (2010), states that learners using PowerPoint slide presentations are more likely to gain a good understanding of science concepts as they learning by doing. Most of these technological and multimedia tools are one of the ways which expose learners to this type of hands-on learning. Therefore, as researchers are beginning to understand fully the situations in which learners learn best, they have found that "the structure and resources of traditional classrooms" are often inadequate and that "technology, when it is used effectively, can bring about better teaching/learning methods that bring a better match to the learning environment." (Perkins, Loeblein, & Dessau, 2010). While most of the studies of technological and multimedia tools used in the learning environment have had mixed results, the best results tend to come out when the technological and multimedia tools are used in teaching natural sciences and, in some cases, mathematics (Perkins, Loeblein, & Dessau, 2010).

Most of the present multimedia technologies enable learners to have interaction with information in new ways, alter change content, and even create their professional academic slides. Because of this interactivity, it enables its users to access a wide variety of content. Scientists normally utilise a lot of technological and media tools in their day-to-day practice, including virtual laboratories and simulations, models of scientific phenomena, and technological tools such as e-mail, video conferencing, and online collaborative knowledge bases such as wikis.

Many of these technological and media tools support hands-on practical work done in the laboratory or field; others enable researchers to view processes such as protein folding that would be impossible to observe otherwise. Many learners may not have access to ICT tools in their classroom environment, hence they can utilise similar technological equipment and multimedia tools to work like scientists; by collaborating with their peers, modeling scientific processes, conducting virtual experiments, and actively participating in research with scientists locally and around the world. Teachers need to be able to evaluate technological tools to determine what suits best his/her learners, class environment, teaching methods, and curriculum (Bryant & Hunton, 2000).

Microsoft PowerPoint is an easy to use tool for most teachers and allows teachers a wide range of options to use when teaching various concepts, especially in the field of science and particularly chemistry, where different techniques are required to teach varying topics.

A PowerPoint presentation is a method or means of communication that can be adjusted to various speaking situations which requires one to get a message across to learners and often contains a persuasive element. PowerPoint presentation is a software package designed to create electronic presentations consisting of a series of separate pages or slides (Hofstetter, 1995). It can further be defined as a presentation program developed by Microsoft which allows users to create anything from basic slide shows to complex presentations for educational purposes. PowerPoint presentation is used to teach large groups as it employs the art of seeking information and stimulating thinking and elaborating at all levels of human reasoning to achieve a given objective. It is used more in demonstrations where the learners can perform activities so that learners can observe how it is done to help prepare theory for practical application. It is useful too when small groups of learners work together to address case-based tasks, exchanging points of view while working through a problem-solving process such as acid-base reactions.

PowerPoint presentation arouses students' imagery systems, which become more activated when information such as instructional materials is presented in non-verbal forms. PowerPoint presentations should arouse the imagery system and could contribute to comprehension, and improve short and long-term memory. Since, in a PowerPoint presentation, topics are presented in a hierarchical fashion with graphics, color, and animation. Clark and Paivio (1991;p.176) states that students could "use a mental image of that outline to study, to retrieve the information on a test, to organize their answer for an essay question, and to perform other educational tasks." Rose (2001) also notes that presentation of learning materials in graphical form is beneficial for students' academic performance. According to Paivio (1998) explains that many studies have empirically tested dual coding theory. For example, relying on dual coding theory, Mayer and Anderson (1991) compare the effect of presentations using words-with-picture with those using words-before-picture, on learning. Both predicted that the words-with-picture group would outperform the words-before picture group because of referential connections between imagery and verbal representations. The results of their study support the prediction. Hofstetter (1995) finds that when pictures and text are presented together, knowledge acquisition and retention is improved.

The study by Armernic (2007) reviews the usage of PowerPoint presentation from four angles, which are effective learning, classroom dynamics, PowerPoint culture and orality, visuality and literacy of PowerPoint. The study's main purpose was to stimulate beneficial conversations about a prevalent educational software technology. It looks at PowerPoint as a powerful and ubiquitous communications technology as an aid to teaching and business presentations. The classroom setting has gone from chalk and talk and occasionally flip and charts to overhead transparencies and to PowerPoint slides. It's important to learn that new forms of communicating call for new ways of thinking about communication processes. The study involved survey methods to collect data. The findings of the study indicate that learners liked to be taught using PowerPoint as they think that PowerPoint presentations are entertaining, enhance clarity and aid recall of subject matter. There was evidence that teaching with PowerPoint leads to significantly better grades than teaching more conventional methods as graphics improve students' comprehension abilities. PowerPoint is more attention capturing than the traditional methods. However, it's worth noting that PowerPoint can also be considered as a teacher centred approach as it puts the instructor at the centre of the action. When PowerPoint presentation is utilised correctly, the presentation is a centre of attraction, especially when used as a valuable communication aid to buttress their rhetoric.

This study is relevant to the current as it makes use of the PowerPoint presentation too. It has highlighted the importance of PowerPoint presentation and how PowerPoint presentation could be used to enhance effective learning. However, this study was just analysing the research on PowerPoint. The current study utilises the PowerPoint Presentation method in the process of teaching. The study equally uses the survey method whilst the current study collects data using the Likert scale and pre-post-test. Furthermore, the PowerPoint presentation would be done in a way that it becomes a learner centred as opposed to teacher centred approach.

PowerPoint presentation mostly combine pictures with texts though videos are used sometimes. However, PhET interactive simulation on the other hand involves animations where variables can be manipulated hence making it more learner centred as compared to PowerPoint presentation.

2.6 Phet Interactive Simulations

PhET stands for Physics Education Technology which is used in teaching Science and Maths based subjects. PhET interactive simulations is a project at the University of Colorado Boulder which is a non-profit open educational resource project that creates and hosts explorable explanations. It was founded in 2002 by Nobel Prize winner Laureate Carl Wieman as it began with his vision to improve the way science is taught and learned. It's a suite of research based interactive computer simulations for teaching and learning chemistry.

Furthermore, PhET interactive simulations are highly interactive. That's the reason they are named PhET interactive simulations. For example, learners can manipulate certain parameters and make observations on the changes in other variables. In this way, PhET simulations allow teachers and students to change variables in response to student's questions, thereby supporting classroom inquiry. Since learners interact with simulations, they benefit by experiencing the concepts involved in the simulations.

This is in line with the majority of contemporary research findings that suggest that learners learn better if they are kept active in the construction of their knowledge within their Zone of Proximal Development (ZPD). Jia (2012) states that learning without being actively involved in the knowledge getting process is meaningless. Additionally, PhET simulations use game-like environments with science-like explorations. In the same vein, Adams (2010) states that with PhET simulations, students engage in scientist-like explorations and that they offer dynamic feedback. In this way, learners are kept active in creating their knowledge, which largely brings about meaningful learning and motivation for learning. This idea is also supported by Vygotsky, a protagonist of constructivism and Seymor Puppet a protagonist of constructionism. In short, learning by doing, makes the acquisition of knowledge easy, interesting and most importantly, meaningful. According to Newcombe (2016), much of the thinking done in science is spatial. Besides, spatial skills are well correlated to performance in science. This means that PhET simulations can improve learner performance by allowing learners to visualise scientific phenomenon. PhET simulations also put learners at ease and allow them to explore (students don't worry about making mistakes that can potentially harm them or destroy equipment).

PhET interactive simulation provides fun, free, interactive, research based science and mathematics simulations. This allows learners to expend all their efforts to learning the science concepts presented in the simulations rather than trying to understand the context of the language used. As a result, this makes the simulations more effective as a learning tool. Perkins et al. (2010) point out that PhET is not cluttered with text and it has a highly intuitive interface that can easily be accustomed to match the teacher's learning environment and goals. Since 2002, Carl Wieman, of the University of Colorado and other specialists in the fields of engineering and science education have been developing a non-profit open educational resource called PhET. The sole purpose was to enhance learning and address specific problems that most students face in Chemistry. The program was created using solid theories of education and with a chemistry learner in mind. PhET interactive simulations have been improved over time and they have become so powerful that they were chosen as the 2011 Microsoft Education Tech award, an honour for technology that benefits humanity.

Notably, the use of PhET simulations in a classroom is consistent with the theories of constructivism. Constructivism stresses the importance of putting learners at the centre of the learning process by keeping them actively involved during learning. Weiman et al. (2002) assert that when students learn in a constructivist manner through the use of computer simulations, they are motivated to actively engage with the content knowledge. This suggests that students' active involvement in the learning process through the use of simulations such as PhET plays a fundamental role in developing positive attitudes towards learning. Consequently, the learners' understanding of scientific concepts and their academic performance are also enhanced. In turn, this can further lead to better attitudes towards content knowledge and the process can continue cyclically. Since the learners' attitudes towards learning inform their academic performance, most educational researchers take a keen interest in understanding whether the teaching methods they use lead to better attitudes towards learning. A common assumption is that if learners are interested in the teaching method that is used, they would also be interested in the knowledge of content that is being taught.

Research done by Wieman (2003) reviews that learners acquire scientific skills, ideas and concepts when they construct their own understanding within the framework of their existing knowledge. In order to accomplish this process, learners must be motivated to actively engage with the content and must be able to learn from that engagement. Wieman (2003) did a quantitative study titled PhET: simulations that enhance learning which incorporated Interactive Computer Simulations which can meet both needs stipulated above. Pre-post tests were conducted on the students. It was found that educationally effective simulations are that learners view these simulations much as scientists view their research experiments. A well designed simulation focuses the students' attention on the basic scientific concepts.

Most of the research by PhET project on design and use of simulation in a variety of educational settings generated the following findings, such as learners doing a two hour exercise using the circuit construction kit simulation in one semester course demonstrating higher mastery of the concepts of current and voltage on the final exam than students who did a parallel laboratory exercise with real electrical equipment. This study is in line with the current studies in that it also uses animation which can be manipulated by the learners to involve other variables. However, the only difference is that with PhET simulations, they are already made and incorporated into the software as compared to the scratch project where the learners are involved in the construction of the animations. As a result, the scratch project achieves better results as compared to PhET simulations.

A mixed study by Basaraba (2012) explored the use of PhET and explored learning simulations on learning concepts in science. This was a quantitative study which used pre- and post-test on two different groups, which were experimental and control groups. This study was done in Canada and revealed that 73% of the learners who used PhET and Explore-learning simulations enjoyed using them. This was a learner centered approach which enabled learners to further explore what they learned in class.

Similarly, a mixed study conducted by Bozkurta and Ilika (2010) investigated the effect of computer simulations on 152 university students who were studying inorganic chemistry. The study revealed that learning with interactive simulations has a positive effect on students' beliefs about chemistry and chemistry achievement as they had better performance when the computer simulations were used in the course of their learning.

Furthermore, a study done by Banda and Chola (2021) on preparation of soluble salts indicates that when computers are well integrated as part of instructional methods during teaching and learning of soluble salts including other chemistry concepts, learners would highly benefit from such strategies. The benefits would be an improvement in learner performance in the acquisition of scientific concepts. In general, this suggests that PhET interactive simulations have the potential to ignite student's interest in learning. This study is related to the current study as it was a mixed study where pre-post test and Likert scale questionnaire were used. However, there were no classroom observations done and this is the major difference between the current study and the study under review. It was further reviewed that the learners had an improvement in both academic performance and attitude of the learners. The learners started enjoying acid-base reaction lessons following the introduction of the learning using computer simulations. As the learners were enjoying learning using simulations, their academic performance improved (Sibinda & Shumba, 2021).

Additionally, a study by Sibinda and Shumba (2021) investigated the impact of PhET interactive simulation and PowerPoint slide show visualisation on learning the balancing of chemical equations to Grade 10 learners. This was a mixed study research which used prominently interviews and pre- and post-test on learners' attitude and academic performance. The study revealed that the experimental group was more effective compared to the PowerPoint presentation slide show method. This is a learner centred approach which depends on the PhET-backed software. However, with scratch projects, learners were able to code the apparatus and create animation to assist learners to acquire skills and knowledge. This is in line with the current study of learning using information and communication technology. When the attitude of the learners improved, the learners had an improvement in the academic performance. This is supported by Banda and Chola (2021) who reviewed that when the learners' attitude improves positively, the academic performance of the learners equally improve. This study was a mixed study more like the one done by Banda and Chola (2021) hence it helped in shaping the methodology of the current study. However, the current study uses the Solomon four experimental design while the study under review uses the quasi experimental design.

In all studies where PhET interactive simulations were used, it has been observed that the learners had better academic and attitude towards learning of science (Sibinda & Shumba, 2021). PhET is embedded software where variables can be manipulated from simple to complex to get desired results. Now, a scratch program which is created to suit the prevailing conditions would be able to bring in better academic performance and learners attitudes. That's why, the next section looks at scratch program as formulated to be used in teaching and learning of acid-base reactions. The scratch program has all the modalities of learning such that all categories of learners are incorporated. Therefore, the learners tend to perform better because all the senses are used.

As the learners manipulate variables, the lessons become more learner centred. As a result, the next section is looking at scratch program which is more hands on activities and effectively interactive as learners build concepts using animations on the scratch program software.

2.7 Scratch Program

Scratch is a free programming language developed by Massachusetts Institute of Technology that makes it easy to create interactive stories, animations, games, music, and art, and share your creations on the web (Dasgupta, 2013). Scratch can run from within a modern web browser or downloaded as an application. Scratch is a high-level block-based visual programming language and website aimed primarily at children as an educational tool for programming, with a target audience of ages 8 to 16. The scratch program site users are called scratchers, where scratch based projects can be created on the website using a block-like screen interface. The scratch program creates projects which can be exported using external tools to other applications, such as JavaScript, EXE files, android and iPhone applications (Dasgupta, 2013). The service is developed by the Massachusetts Institute of Technology Media Laboratory, has been translated into seventy plus languages, and is used in most parts of the world. The scratch program was taught and used also in after-school centres and public knowledge institutions besides schools, and tertiary institutions. As of May 2022, community statistics on the language's official website indicate that more than one hundred and four million projects were shared by over ninety million users. In fact, there were over six hundred and eight six million total projects created, which includes unshared projects. As for website visits, there were more than one hundred million per month (Becky, Choi, & Juan, 2013).

The Scratch program derives its name from a Disk Jockeys (DJ) technique called “scratching”. During the scratching process, mostly disk Jockeys (DJ) use the vinyl records by clipping them together and then manipulating them on a turntable to produce a variety of sound effects and music (Brennan, 2012). In the same way as the Disk Jockeys perform scratching, the scratch program website allows users to combine different media such as graphics, sound, and other programs together, so that video games, animations and simulations can be integrated in creative ways for teaching and learning various concepts.

The Scratch program interface is split into three main areas called a stage, block palette, and coding areas. The coding area is a place where blocks are arranged into concept scripts that can be run by pressing the green flag or clicking on the code itself (Brennan, 2012). However, the users may also create their own code blocks, and they would appear in "My Blocks".

The coded concept results such as animations and graphics are featured on the stage area of the scratch program. The stage area allows these coded results to appear as either small or normal sized features of concepts. All the sprinters are displayed at the bottom area. The stage area therefore uses x and y coordinates, with 0, 0 being the stage centre (Becky, Choi, & Juan, 2013).

When a sprite selected is at the bottom of the staging area, blocks of commands can be applied to it by dragging them from the block palette into the coding area. The appearance of the sprites can be changed by users using the costumes tab. As a result, various effects on the animations are created using a vector and a bitmap editor. The concept narrations can be added to a sprite using the sounds tab in the coding area.

When sprites are being created, including their backgrounds, the user can draw their own sprite manually by choosing a Sprite from the library, or by uploading an image. Dasgupta (2013) describes Scratch as a computer programming language that lets you create your own interactive stories, animations, games, music, and art. Scratch is easy to learn and use as it provides an interactive environment which enables learners to drag blocks of code in order to create concept scratch programs.

Therefore, Nsabayezu and Iyamurenye (2022) conducted a study which investigated teacher's conception and reflection of computer programming from scratch in terms of technological and pedagogical stand point. The study was a mixed research approaches typically achievement tests and interviews were used to collect quantitative and qualitative data respectively. A paired t-test was used to analyse qualitative data from pre-post while descriptive and interpretive analysis were used to analyse qualitative data from interviews. The results of the study showed that mathematics and science teachers have a great conception of programming after attending scratch programming. It was also found that scratch program is an effective pedagogical tool for teaching and learning mathematics and sciences. Teachers expressed positive views of using scratch in teaching and learning mathematics and sciences as it helps them to visualise abstract content, motivate students, increase student's interest, critical thinking and problem solving skills act as an assessment tool and increase student's academic performance (Darhmasur et al., (2015).

This study by Nsabayezu and Iyamurenye (2022) was relevant to the current study as it shows that teachers are able to be trained to use scratch in the teaching and learning process of acid base reactions. The current study too is a mixed study using both quantitative and qualitative data specifically in acid base reactions of the chemistry subject. The current study used the Likert scale to also analyse the attitude of the learners when using the scratch program to learn acid base reactions. The Friedman's test was used because the current study had four independent groups.

However, the current study departs from Nsabayezu and Iyamurenye (2022)'s study in that the data was normally distributed but the current study had its data not normally distributed hence analysed using a non-parametric test Friedman test as compared to test. Besides, the pre-post test and interviews, the current study used also the Likert scale and the observations to collect data compared to the study of Nsabayezu and Iyamurenye (2022).

Additionally, Sungki, K., Hee, C., and Seoung-Hey, P (2019) conducted a study on teaching Bronsted-Lowry Acid-Base model using the scratch program in order to improve the student's understanding. The Bronsted-Lowry acid-base model requires complex systems thinking because it considers random interactions between reactant and product particles and effective particle collisions in forward and reverse reactions. The title of the study was Using a system thinking approach and a scratch computer program to improve students' understanding of the Bronsted-Lowry Acid-Base Model. In order to understand the ontological attributes of science concepts, such as the Bronsted-Lowry Acid-Base reactions, a scratch program was created to improve the understanding of the Bronsted-Lowry Acid-Base reactions. This was a quantitative study which used pre-post test to collect data as it employed a quasi-experimental design. The data was analysed using a paired t-test. The findings revealed that the experimental group had better academic performance as compared to the control group.

This study is relevant to the current study as both uses the pre-test and post-test to collect the data. The current study employs Solomon Four group design while the study by Sungki, K., Hee, C., and Seoung-Hey, P (2019) had a quasi-experimental group design. At pre-test stage both studies reveal that the learners in both experimental and control groups had the same knowledge as they retained the null hypothesis.

However, the two studies depart on that the current study is a mixed study which looks at both attitude and academic performance of the learners whilst the previous study only looks at the academic performance of the learners. The current study used a non-parametric test Friedman's test to analyse the pre-test and post-test while the previous study used the paired t-test to analyse data. Nsabayezu and Iyamurenye (2022) supports the study that using t-test, quantitative data from both pre and post test could be analysed.

A study done by Becky, Choi, and Juan (2013) at Boise State University in the United States of America was also on the scratch program. The aim of this study was to create instructional method which could improve learners' content knowledge as well as important skills for success in the 21st century. This would include producing an instructional intervention on mathematics which can enhance learners' positive attitude toward mathematics through learning by making games. In the end, the researcher created a computer-aided instruction which embedded the Scratch program. This scratch programming tool was created following the mathematics curriculum to provide practical instructions which were in line with the 21st century learning skills and positive attitude toward mathematics. The study was a quantitative one where the learners did pre-post test and Likert scale questionnaire. This was quite different from the current study as it's a mixed research study where interviews and observation were being used to provide qualitative approaches so that the attitude of the learners could be understood. As a result, the case study used the developed scratch program intervention which reviewed that there was a great possibility to have the program as an alternative way to learn mathematics in ways that would stimulate learners' various abilities, such as creativity, problem solving, logical thinking and the like, as well as that build a positive attitude toward Mathematics. The positive attitude of the learners made the learners to start enjoying learning mathematics and their academic performance improved.

This study by Becky, Choi, and Juan (2013) has been relevant to the current as it promotes development of creativity, problem solving, logical thinking and inculcating positive attitudes to the learners. The learners when they learn acid-base reactions using the scratch program, they acquire problem solving skills and logical thinking skills as they manipulate spikes and stages to create titration experiments. The two studies investigates on how scratch program could be used to improve learners' academic performance and attitude.

However, the two studies depart from each on the concepts they address. The current study uses scratch program to teach the acid-base reactions while the study by Becky, Choi, and Juan (2013) uses scratch program to teach mathematical concepts though it's both practical way of teaching which is being promoted. The current study is action oriented while the previous study was a case study which employed scratch program.

A study by Brennan, (2012) done at Doctor of Philosophy level explored learning using Scratch project. The study used scratch which adopted a predominantly qualitative approach to explicitly explore learning in a computational culture by studying how the Scratch programming environment and online community are employed to support learning both in and out of school. Using a theoretical framework of agency and structure, the researcher analysed how the at-home and school-classroom contexts enable or constrain the young people's agency in computational creation. This is true for scratch, as what learners' code during the learning process can be useful when learners take it to the outside classroom environment. This means that learning continues even in their homes. Despite common assumptions that at home learning is necessarily low structure/high-agency and that at-school learning is necessarily high-structure/low-agency, she argued that structure and agency need not be in opposition.

This is supported by the current study where learners could continue learning even in the absence of the teacher. This study is relevant to the current study as both are mixed research study. Intermediate possibilities should be explored by learning environmental designers so that alternative ways could be employed in the service of a learner agency. Indeed, effective learning should be done both in school and at home. Therefore, the bringing in of a scratch program would enable the learners to learn on their own at a pace in their homes.

However, the two studies depart from each other in that the current study is a mixed study but the previous study was a purely qualitative study. The previous study used the interviews and document analysis to collect data which helped the researcher to collect data on the performance of the learners when they were outside the classroom. The activities of the learners are able to be traced from the activities performance which they engage themselves when they are at their homes.

In addition, a study by Armoni (2015) investigated the use of the scratch environment for teaching computer concepts in secondary school. The title of the study was from scratch to real programming, which meant that the learners learned from a scratch program to enhance learning in the classroom environment. This was a quantitative research whereas the current study is a mixed study. This study shaped the way quantitative approaches to research could be done. As a result, the paper finds that programming knowledge and experience of learners who had learned from scratch greatly facilitated learning the more advanced materials in secondary school, less time was needed to learn new topics, there were fewer learning difficulties, and they achieved higher cognitive levels of understanding of most concepts, although at the end of the teaching process, there were no significant differences in achievement compared to students who had not studied scratch. However, the final findings showed that there was increased enrolment in computer science classes and students were observed to display higher levels of motivation and self-efficacy. This research justifies teaching computer studies in general and visual programming in schools.

This study is relevant as it forms a foundation on which scratch can be introduced as part and parcel of the topics in computer studies, such that the science based subjects can tap into the skills to teach scientifically based skills and knowledge. The virtual laboratories would be of great value in schools where the conventional laboratories are not functioning. Besides, the attitudes of the learners would be improved as they use a digital platform.

The two studies differ in that the current study employs the acid base reactions as compared to the computer studies the previous study was conducted on. The previous study therefore was more qualitative as compared to the current study which is a mixed study. In a mixed study, both qualitative and quantitative data are collected.

Besides, another study was by Darhmasur et al., (2015), which focused on finding pedagogical solutions to overcome learning difficulties in the use of games in the learning process. In fact, these games are more likely to boast the motivation of students and allow them to develop their knowledge efficiently. The title of the study was learning basic programming concepts by creating games in a scratch programming environment.

The study allowed students to create simple games using the scratch games environment in order for them to learn programme basics. This research was conducted on sixty-nine high school learners. This was qualitative research where two surveys were distributed at the beginning and at the end of the experimentation in order to identify the programming level of students, their gaming habits, their motivation and interest in programming in the future. The analysis of the survey shows that using an environment for learning programming such as scratch highly motivates students and empowers them to pursue their studies in programmes. In fact, when learners asked about their desire to continue their students in programming they considered continued their studies in programming and showed great interest in the study.

This study is relevant to current studies. The interest of learners in programming would enable them to create more games which they could use in learning scientific concepts and knowledge on their own. As they learn on their own, the learners would become autonomous learners. As a result, it would enable learners to spend a lot of time on learning scientific skills and knowledge.

Another study of interest is by Belessova et al., (2024) which investigated the impact of the scratch programming environment on student engagement and academic performance in primary informatics education. This was a mixed study which involved observations, focus group discussions and end of trimester tests. The student engagement instrument was used to assess cognitive emotional and behavioural engagement and academic performance was evaluated based on trimester grades in informatics. The results indicated significant improvement in both learner engagement and academic performance post implementation of scratch.

This study is relevant to the current study in that it uses a mixed study research design as well as investigating the effect of scratch program on both pupil engagement and academic performance. According to Darhmasur et al.,(2015) supports that mixed study research approaches look at both qualitative and quantitative in order for the study to bring out relevant aspects from the participants in terms of responding to the research questions. Both the current study and Belessova et al. (2024) created a scratch program which was used to teach the learners concepts in science.

However, the current study and Belessova et al.,(2024) differ in that the current study looks at attitude of the learners as a pre-requisite of engagement. Besides, the current study took

into account the Likert scale, observations and interviews as the instruments used to collect qualitative data whilst pre-test and post-test were used to collect quantitative data.
The next section looks at learners' attitude towards virtual laboratories as the study looks at both the attitude and academic performance of the learners.

2.8 Learners' Attitude towards Virtual Laboratories

Akinbobola and Ikitde (2008) submit that attitude may be defined as beliefs and opinions that can predispose an individual to behave in a certain way. Oskamp and Shultz (2005) define attitude as a predisposition to respond in a favourable or unfavourable manner with respect to a given object. Oskamp and Schultz (2005) posited that the behavioural attitudinal responses are not behaviours per se, but are the person's action tendencies toward the attitude. In short, the cited definitions above focused on attitude as consisting of both cognitive and affective domains. The current study would determine the impact of collaborative learning on learner attitude towards environmental education concepts and issues in chemistry. Attitudes towards environmental education concepts and issues in chemistry, which are the focus of this study, essentially and predominantly, have an affective orientation such as liking, enjoyment of the object 'chemistry'.

The study by Denila (2010) investigated the relationship of high school chemistry students' motivation to learn and attitude towards chemistry with their chemistry academic achievement. The study was titled the relationship to learn and attitude towards chemistry on the academic achievement of high school chemistry students. The data in this study was collected by using both a Likert scale and an achievement test to determine the correlation between attitude and academic performance. The findings reviewed that good attitude was necessary for students to perform better academically. Denila (2010) points out that the attitude of the learner towards learning determines the level of engagement of the learner with the material they are learning even after classroom sessions. This means that a student's attitude to learning determines their ability and willingness to learn.

The learners who are more motivated always learn better than those who are less motivated. That's why Denila (2010) asserts that if a child has a positive attitude and likes school work, the child would experience some success and would work more effectively. Thus, educators need to look for means and ways of encouraging learners through better teaching and learning methods so that they develop a positive attitude towards learning. Such ways include use of collaborative learning, integrating environmental education issues from the learners' local community.

Talking about virtual laboratories, a favourable attitude shows a greater probability that learners would accept the new learning systems. Factors such as patience, self-discipline, and easiness in using software, good technical skills, and abilities regarding time management impact on learners 'attitude towards virtual laboratories.

Therefore, the attitude can be said to be positive when the new form of education suits the learners' needs and characteristics, whereas it is negative if the learner cannot adapt to the new system of education because the learner does not have the set of characteristics required (Bertea, 2009). Bad e-learning perception may be due to lack of understanding, lack of communication, and lack of trust or conflicting agendas in appropriate use of technology. Some goal coaching and awareness exercises are probably needed to strengthen people's perception. It is important to realize that learners are both emotional and intellectual; and emotions have a lot of effect on people's perception and what they do (Ndume, 2008).

Technology acceptance is defined as "an individual's" psychological state with regard to his or her voluntary or intended use of a particular technology". The e-learning platform developers and deliveries need more understanding of how learners react and perceive the elements of e-learning along with how to most effectively apply an e-learning approach to enhance learning (Bertia, 2009). In addition, knowing students' intentions and understanding the factors that influence students' belief about e-learning can help academic administrators and managers to create mechanisms for attracting more students to adopt this learning environment (Bertia, 2009).

A study by Adewole (2014) investigated the attitude of students towards E-learning. This was a qualitative study done on the attitude of the students towards E-learning in southwestern Nigeria which indicated that there was an undisputed relationship between attitude and the success of E-learning. The study was quantitative and used the Likert scale as it looked at the attitude and e-learning relationship with the application of the Technology Acceptance Model (TAM). The findings of the study indicate that there is a significant relationship between perceived usefulness and the attitude of students towards the use of e-learning systems. The attitudes of the participants improved when e-learning was employed in their day to day learning as compared to traditional learning. This study is important to the current study as both use the Likert scales to measure the attitude of learners towards the computer based Information and Communication Technology(ICT) teaching methodologies. However, the study didn't use other qualitative approaches such as interviews to gain more insights into the attitude of the learners. The interviews would have allowed the learners to spell out what made them motivated.

Another study of interest was done by Cengiz (2010) who looked at the attitude of the grade nines by using virtual laboratories to teach scientific concepts. This was a qualitative study which was based on attitudes of learners in 9th grade the relationship it had with its results as an implication for teaching the chemistry topics. It was revealed that virtual laboratories as they used virtual experiments affected students' attitudes towards chemistry positively. In chemistry education, laboratory activities increase students' interest in the subjects covered in the class and help understand concepts during the learning process. Due to lack of laboratories at schools or insufficient instruments in laboratories, hands on experiments are rarely performed in state schools in Turkey. Due to this inadequacy, however, such important experiments can be virtually done as a result of recent developments in Information and Communication Technology. Therefore, virtual laboratories have become the best alternative to enhancing learning science practically in the class as physical experiment were not able to be done due to lack of laboratories in the school set up. This piece of writing is important to the current study as it was based on attitudes towards learning chemistry concepts which would include the current study which is looking at teaching Titration using virtual laboratories as a centre of the learning of Acid, Base and Salts.

A study by Chola and Banda (2021) explored the impact of computer simulations in terms of attitudes on learning preparation of soluble salts. The study as indicated earlier was a mixed study that used both quantitative and qualitative methods. This study on the impact of using computer simulations on the performance of grade 11 learners in preparation of soluble salts reviewed that positive attitudes were gained by the learners. They used a Likert scale attitude questionnaire where the findings showed that the learners' attitudes had improved from pre-intervention to post-intervention. The general results therefore indicated that the learners had agreed to learn to prepare soluble salts through computer simulation integration. It can be concluded that when computers are part of learning in a science classroom, learners tend to possess positive attitudes toward the learning of chemistry.

The study by Sumedha and Senevirathne (2024) was to find the relationship between student attitudes and student achievement in chemistry subject. The analysis of the results of the Sri Lanka examination department clearly revealed that science subjects had lower marks as compared to other subjects. The purpose of the research was to find out the multivariate correlation and effect between students' attitude towards the subject of chemistry and student achievement. It was a quantitative design conducted from thirteen (13) secondary schools in kegalle education zone in Kegalle district of Sri-Lanka. Confirmatory Factor Analysis (CFA) was conducted to confirm the validity of the questionnaire for measuring students' attitude towards the subject. An exploratory data analysis (EDA) was first conducted to validate the data collected. Data analysis was conducted using descriptive and inferential statistical methods. It was identified that there is a positive correlation between attitudes towards the subject and student achievement.

This study by Sumedha and Senevirathne (2024) is relevant to the current study as both uses Confirmatory Factor Analysis (CFA) to have questionnaire items reduced and also to validate the instrument. This study uses the Likert scale which was validated by the Confirmatory Factor Analysis which reduced the questionnaire items from thirteen to four using the rotations. Both studies also analysed the data using descriptive and inferential statistical methods.

However, the two studies differ in the research methods such that the study by Sumedha and Senevirathne (2024) was a quantitative study while the current study was a mixed study. The current study uses pre-post test for collecting quantitative data while the interviews and observations were used to collect qualitative data.

Another study of interest is by Yunus (2018) who investigated using qualitative research methods the reasons why high school learners were losing interest in chemistry as it was able to give solutions to the environmental challenges communities were facing. The title of the study was attitudes towards learning chemistry among secondary school students in Malaysia. The data was analysed using Qualitative Data Analysis (QDA). The findings revealed that majority of the learners have a positive attitude towards learning chemistry when laboratory activities are conducted during the learning process and also when the learning modalities are attractive. However, the findings also revealed that most of the learners had negative attitude towards chemistry because they lack interest in the subject and syllabus as a whole.

This study is relevant to the current study in that both analyses qualitative data using Qualitative Data Analysis (QDA). The current study despite being a mixed study uses the Qualitative Data Analysis to analyse the qualitative data collected from interviews where themes were generated. It furthermore supports that the interest of the learners towards learning chemistry would be aroused when the learning process is punctuated by practical activities. Therefore, this study employs the practical approach of learning acid-base reactions using scratch program to arouse the interest of the learners.

However, the two studies differ in that the current study is a mixed study where both qualitative and quantitative data is analysed for academic performance and attitude of the learners. This combination of attitude and academic performance of the learners would result in the interrelation between the attitude and the academic performance of the learners. It investigates the relationship between the attitude of the learners and their academic performance which the study by Yunus (2018) would not achieve.

A study by Kaoka (2023) investigated the effect of virtual laboratory on the achievement of tenth grade students and their attitude toward Chemistry. The title of the study was the effect of using virtual laboratory on the achievement of 10^{th} grade students in acid-base and their attitude toward chemistry. This was a quantitative research method that adopted a quasi-experimental in nature. The experimental group was taught acid-base reaction using a crocodile chemistry 605 software while the control group was taught using a traditional lecture method. The data was analysed using the independent sample t-test. The findings of the study revealed there was a significance difference in terms of attitude and achievement between students of both groups in favour of the experimental group.

This study is relevant to the current study as it is used a pre-post test and Likert scale to investigate the effect of the virtual laboratory on both academic and attitude of the learners when teaching acid-base reactions. The current study analysed the Likert scale using Mann Whitney U test while the study by Kaoka (2023) analysed the data using the independent t-test. Yunus (2018) supports that an improvement in attitude results in the improvement of academic performance of the learners.

On the other hand, Acar Sesen and Mutlu (2020) did an experimental study which was comparing the attitude of prospective science teachers towards chemistry laboratory and chemistry lesson delivered via inquiry based instruction method in real and virtual laboratories. The study was titled comparison of inquiry based instruction in real and virtual laboratory environments: Prospective science teachers' attitudes. This was a mixed study designed on both quantitative and qualitative data. The findings revealed that although all prospective science teachers'attitudes chemistry lesson and laboratory improved significantly in both real and virtual laboratory environments, the improvement in there scores in a real laboratory environment was significantly higher than that in the virtual laboratory. This results were in contrast by Chola and Banda (2021) which revealed that the learners exhibited significant results in computer simulations as compared to traditional experiments. This is the more reason this study is being conducted as it would determine the attitude of the learners towards scratch program.

Furthermore, a study done by Mwamba (2021) on Physics Education Technology (PhET) simulation revealed that learners had a positive attitude towards learning Electromagnetism. The study investigated the impact of using PhET simulations in teaching electromagnetism on the learners' performance as well to establish the impact of using PhET simulations on the learners' attitude towards electromagnetism. The title of the study was the impact of using PhET simulations in teaching electromagnetism on learners' performance and attitude. This study was quantitative research which employed non-equivalent group pre-test post-test quasi-experimental research design. The findings of the study were that PhET simulations had a significant positive impact on the learners' performance in electromagnetism. PhET simulations equally had a significant positive impact on the learners' attitude towards electromagnetism. In fact, the learners' motivation towards learning electromagnetism improved with the involvement of PhET simulations. Therefore, it meant that PhET simulations were not only able to improve the learners' performance, but they also gave the learners the motivation to continue learning. The study is in line with current studies as it assesses both the learners' academic performance and attitude. However, the difference is that the study by Mwamba (2021) did not use the qualitative analysis where the learners would have spelled out exactly what they learned to have had a change in attitude towards learning electromagnetism.

However, PhET interactive simulations has a limitation of being interactive except being manipulative. On the other hand, scratch enable learners to develop critical thinking and problem solving skills as learners create scratch projects. As learners create their projects, they express their creativity and become more fluent with technology. The scratch program provides a better interactive platform such that learners can create animations using the sprites and the "my blocks". Scratch program promotes collaboration and communication skills as learners share their projects with each other. As a result, scratch program promotes high retention of the learnt concepts. However, this scratch program has been underutilised hence the need to explore the attitudes and academic performance of learners.

2.9 Directions from Literature Review

From the literature presented, all the studies emphasise the use of real-world problems in the learning and teaching of chemistry. Use of ill-structured problems as a starting point for learning fosters the development of critical thinking, problem solving skills and collaborative learning. When students encounter real-world problems that directly affect them, they become more engaged with the subject and develop a deeper level of understanding (Szozda, 2007).

The role of academic institutions and authors is to transform the knowledge to be taught in schools by first delineating its boarders followed by the process of reorganization. Then the teachers use classroom activities to transpose the knowledge in the curriculum and textbooks, into knowledge that can be presented to learners. Teachers use various methods to transform the concepts into a form that can be understood by the learners. The knowledge that is learned in school is knowledge that has been filtered, transposed and interpreted by institutions of learning and educators (Andoloro, 1997 & Pakdag, 2010).

The literature reviewed shows that most studies done in virtual laboratories compare the impact of computer simulations on learners' academic achievement to that of traditional (teacher-centred) methods. However, the current study would assess the effect of a virtual laboratory on learning acid-base reactions, which is a good method of teaching. This study further looks at the effect of virtual laboratories on learner performance and attitude.

2.10 Chapter Summary

This chapter has outlined and discussed various literature reviews and studies related to virtual laboratories, such as scratch programs and PowerPoint presentations and, lastly, the traditional approach. The literature discussed in this chapter sets the background necessary to examine a learner centred approach to intergrading scratch programme in the teaching of chemistry concepts. This chapter has further given an overview of related studies whose findings inform the present study. The next chapter presents the methods and procedures the researcher would adopt in the experimentation, collection of data and data analysis, which would enable it to be possible for the researcher to answer the research questions that guide this study.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Overview

This chapter presents the titration scratch program project, research design and the philosophical perspective that underpinned the research process. It explains the processes for selecting participants for various data collection instruments used in the study. The data collection instruments are discussed in terms of how they were developed and their suitability in this design. It also presents the data collection and analysis and concludes by discussing the validity, reliability, limitations and ethical consideration.

3.2 Creation of Titration Scratch Program

The production of a scratch program was done in line with the principles of multi-media learning which include learning modalities of the brain. When a learner is exposed to new information from the various senses (modalities), the brain needs to form an association between what is seen and to some extent what is heard, which are then encoded by different groups of neurons in various parts of the brain. Learning is a neurobiological process indicated by the growth and strengthening of connections between neurons (Dumbo, Myron, & Howard 2007). As a result, there was a great need to create a program which would support effective learning following how the senses grasp the information using the cognitive learning strategies. Cognitive learning strategies are methods used to help learners link new information to prior knowledge in facilitating the transfer of learning through the systematic design of instruction hence the titration scratch program created (Coffield et al., 2004). As result, significant retention of knowledge in learning process can be accomplished through the informed use of visual and verbal multimodal learning which the scratch program is able to provide.

Moreover, the creation of the scratch project was also riding on multimedia programming which is a topic taught in both mathematics and computer studies. Under programming, the learners learn the process of coding such that they attach concepts to stakes on the scratch program. This is therefore a learner centred approach as it speaks to being kinesthetic on the learners besides riding on the audibility and visibility of the scratch program. At junior secondary level, computer studies is a compulsory subject making the learning of coding in scratch program as manageable.

Therefore, the study initially created a titration project on titration laboratory activity which included procedures and calculating the volume of the acid when there was a known volume of the base using the scratch program software. This program used codes to name the apparatus, conduct the experiement and also made a narration on the volumetric calculations which were used in the titration experiement. This was all made into animations such that each apparatus was named as they were being arranged for the experiment. Equally, the colour changes of the indicator was showed when the end point of the experiement was reached as depicted. Thereafter, scratch program software was installed on the available computers in the computer laboratory at each school. The learners were given time to observe the scratch program thereafter they were taught simple coding techniques which could be used to code laboratory apparatus. This skill would enable learners to learn concepts whilst their teacher is not around and have meaningful usage of digital gadgets at their home. This was possible because scratch program is a free visual programming language and an online community which can assist in creating interactive stories, games and animations.

This project on titration was used as a teaching technique to assist in understanding the concept of titration against an already known teaching technique of power point presentation slide show visualisation. The study created the scratch program titration project using the scratch software programming so that it is compared to an already known PowerPoint presentation teaching technique. Most of the presentations which are made either in contact or online, are done using PowerPoint technique which include the teaching and learning process. You tube videos were embedded in the powerpoint presentation slide show visualisation.

Initially, it was observed that teaching was done through talk and chalk hence the redundancy principle was considered. This principle states that learning can be hindered if the same information is presented simultaneously in multiple forms, such as spoken and written text (Mayer, 2009). In designing the scratch program project, only relevant concepts were considered for the learners to gain the necessary skills and knowledge to avoid overloading learners with redundant information. Therefore, the scratch program project balanced both the animations accompanied by the narration so that cementation of the concepts was done. This approach enabled the learners to maintain their cognitive resources for deeper understanding and application of acid-base reaction concepts.

Figure 3.1 shows the picture of the animation which was created from scratch project to show the neutralisation reaction between hydrochloric acid and sodium hydroxide as an example of an acid-base reaction.

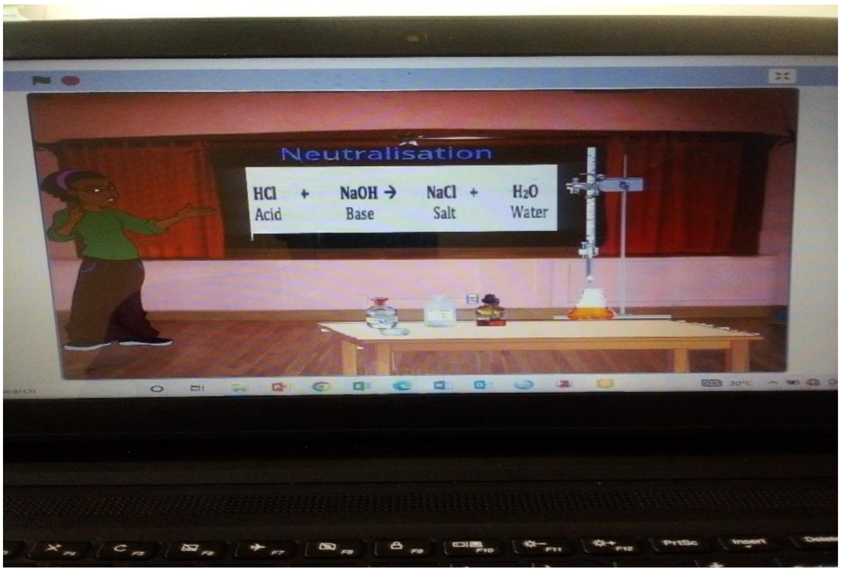

Figure 3.1: Scratch program on acid-base reaction.

Figure 3.1 shows the arrangement of a titration experiement animation which was accompanied with a narration on what is happening. The animation showed the change of colour when the acid-base reaction reached the end point. The apparatus and narrations were coded and timed such that the learners follow the steps and calculations. Several learner centred approaches were considered and principles were included for the better retention of the concepts.

The first principle was that of multimedia which was used to create the scratch program where pupils learn better from words and pictures than from words alone as the scratch program provides videos that are pictures moving rapidly(Coffield et al., 2004). Multimedia learning is learning from printed or spoken text and static or dynamic pictures (Mayer, 2008). The author attributes multimedia learning to the broad theory of the science of learning. The theory stipulates that humans possess separate channels for processing visual and verbal material, each channel can process only a small amount of material at any one time and that deep learning depends on the learner's cognitive processing during learning such as selecting, organizing, and integrating. This is because the brain searches the memory using context such that where there is no clue, the brain formulates the mental pictures. The scratch program involves both pictures and words to support effective learning.

The coherence principle emphasizes that learning is more effective when extraneous information is excluded, allowing learners to focus on the essential content (Mayer, 2009). In the context of this study, the scratch program was designed to eliminate any irrelevant material that distracted learners. By presenting concise and focused content, it is hoped that learners would concentrate on the key elements of acid-base titration, thereby enhancing their understanding.

The scratch program was created basing it on the personalization principle which asserted that learners learn better when the instructional material is presented in a conversational style rather than a formal style (Mayer, 2009). In this study, the scratch program adopted a more group discussion approach, making the acid-base reaction concepts more relatable and engaging for Grade 11 learners. This approach increased learners' motivation and interest in the subject, thereby improving their overall learning experience and outcomes.

Another principle which was used to create the scratch program was the segmenting principle which suggested that learning was more effective when the concepts are presented in manageable chunks rather than as a continuous stream (Mayer, 2009). Scratch program was segmented into codes where each focused on specific aspects of titration experiements. This allowed learners to process and understand one segment before moving on to the next, facilitating a more structured and incremental learning process.

Generally when Scratch projects are being used, they enhance group work as learners solve tasks collaboratively, encouraging teamwork and peer learning. As a result, there is meaningful learning among the learners as they share ideas, skills and knowledge. Besides, as learners are assigned to group tasks, they are required to collaborate on coding projects, therefore improving their communication skills and problem solving abilities as they work together to solve the academic problems provided by the teacher.

Another guiding factor which was considered was that of connectivism theory on scratch program. When the learners use scratch program in the learning process, it shifts the learning responsibilities from the teacher to the student. In this process, its upto the learner to create their own learning experience. This results in learners having the process of learning done both in class and outside class. The learners become more responsible for their learning process and attaining the outcomes of the concepts learnt.

3.2 Embedding of PowerPoint Presentations Videos

The researcher embedded some youtube videos on the PowerPoint presentations so that the learners could watch how titration was done. This enhanced some learning modalitities such as visual and auditory combined in the teaching aid. In this regard, learners who learn better by combining both auditory and visual aspects of learning were given an opportunity to learn.

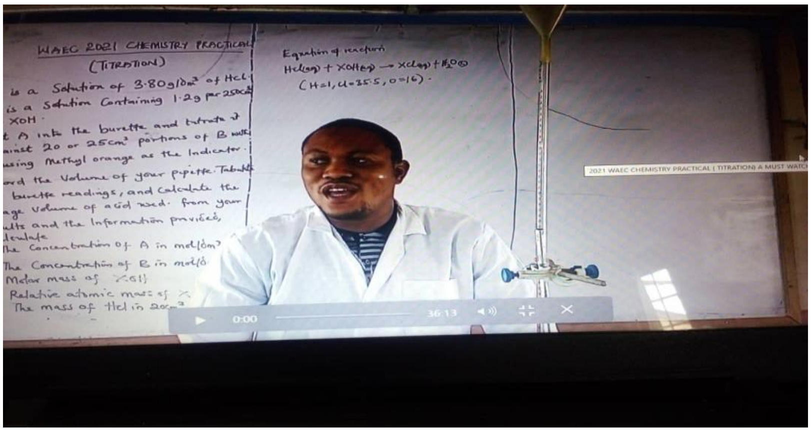

Figure 3.2: PowerPoint presentation Video

When multiple senses are engaged like sight and hearing, learners are engaged in the learning process hence creating a memorable experience for their learning as clarity is made. It further helps to make the learners retain effectively more concepts. It would further enable the learners to have supplementary material for their classes. Powerpoint presentation would be engaging in this way as compared to just a visualisation being done.

The modality principle which suggested that learners learn better when information is presented through a combination of auditory and visual channels rather than through a single modality was used in creating the video for the lessons(Mayer, 2009). In this regard, learners tend to acquire concepts better from multimedia lessons when graphics are explained by audio narration than onscreen text. The PowerPoint presentation video had both graphics and animation which would enabled the learners to conceptualise the process of neutralisation. Therefore, learning is better enhanced when corresponding words and pictures are presented near rather than far from each other on the page or screen.

3.3 Research Paradigm

This study is grounded in the pragmatism theory of learning as demonstrated by the conceptual framework. Pragmatism is an approach to the learning that evaluates theories in terms of the success of their practical application. The pragmatism point of view refers to the characteristic of primarily focusing on the practical applications of ideas and thoughts, rather than their theoretical ideologies and abstractions. Through being pragmatic, an individual seeks to find the ideal solutions to a problem through practical activities which lead to finding the truth (Lewis, Thornhill & Saunders, 2012).

Pragmatism emphasizes on project based learning, play based learning, experimentation and experiential learning.The pragmatic approach use is centred on the discovery method which is mostly suitable for the research problem identified. It rejects unpractical ideas as it focuses on the real world applications of lessons. It has four main principles namely utility, interest, experience and integration. At the moment, the digital age supports laboratory activity hence the link with connectivism theory that provides insight into learning skills and tasks needed for learners to flourish in a digital era(Stephenson, 2004).

The first principle of pragmatism is utility where concepts taught and learnt are suppose to be useful to the learner. The concepts learners acquire are need to be relevant and useful such that the learners are effectively engaged and eager to learn. It means the knowledge which the learners is suppose to have add value to the lives of the learners. Therefore, as the learners are engaged in the learning process, it should be learning in context to the environment the learners are found. The second principle is the interest where the learners' interest should be put into practice such as conversation, investigation, construction and creative expression. Teachers to plan and focus on lessons where learners can talk to one another, investigate things, make things and become creative as its an effective way to nurture information (Stephenson,2004). Therefore, the teacher should help in the nurturing of the knowledge, skills and concepts through use of digital platform gadgets.

The third principle is experience where effective learning can only take place when learners experience concretely what they learn otherwise abstract learning is more idealistic without practical use. Teachers, therefore should create a lot of project based experiemental and experiential lessons that help pupils to learn by doing. The fourth principle is integration where learners can link concepts from different subjects and encourage a holistic understanding of the topics they are learning.

As a result, the linking of pragmatism to connectivism is in line with the 21^{st} century skills which advocate readiness in every student by promoting the fusing of the three(3) Rs(writing, reading and literacy) and the four(4) Cs(Critical thinking and problem solving, communication, collaboration and creativity and innovation)

It appreciates learning in the digital world where learning can reside outside an individual such as in the database of a learning institution hence a need to access it. It specialises in connecting the information sets which enable learning to take place. Network learning is important than traditional learning. Social network is important and technology enables the network to take place. The relationship that exists between people make it easier for learning. It cuts on distance between the source of knowledge and the learners. It connects with social constructivism where as learners interact learning takes place.

It was from these perspectives that the study would use integrated mixed methods research design in order to assess and understand the effect of scratch program project on learners' attitude and achievement performance in acid-base reactions. The pragmatic approach would help in enhancing practical skills in both teachers and learners so that the science lessons are taught and learnt practically. Knowledge is derived using scientific method and based on sensory experience gained through experiments or experiential learning. It aims at developing a unique and elegant description of any chosen aspect of the world that is true regardless of what people think as long as it can be proved practically or through experience. By developing these scientific facts, knowledge is built up as it is proved practically and accepted as the truth at that moment. Pragmatists believe that the truth changes with new knowledge which is acquired.

Therefore, science builds on what is already known hence the new teaching approaches would be emerging from the already existing ones. The approach to knowledge is reductionist in character, by maintaining that less measurable sciences are reducible to more measurable ones. This resonates with objectivism, one of the ontological perspectives, which holds the view that personal values should not be allowed to intrude in a research(independent), external and that reality is still in the making and awaits its party of complexion from future (Lewis, Thornhill & Saunders 2012,p.131). The argument of this philosophy is that beyond scientific methods of observation and experimenting is logic and mathematics.

Pragmatism believe that actions reflect an accumulation of verified facts expressed as laws. The goal of science is to formulate generalised laws (Creswell, 2003). Pragmatism philosophy follows a highly structured methodology in order to facilitate the hypothesis, works on quantifiable observations from experiments and accordingly statistical analysis is obtained. Therefore, pragmatism concerns the use of statistical data, and believe that it is possible to classify the natural world in an objective way, therefore it is then possible to count sets of observable scientific facts to produce laws and theories.

This position is underpinned by the connectivism theory. It was therefore, important to understand the objectivity reality of teachers of chemistry and learners in order to make sense of their understanding and difficulties in the practical work so as to introduce laboratory acivities using the virtual laboratories applications.

The purpose of the study was to develop titration experiment using scratch program which can be utilised in improving learners' academic performance by using more practical activities. In order do this, it was imperative to gain significant indepth understanding of both scratch project program technique and acid-base reactions. For an in-depth understanding of the above components of the research questions it was important for the design to be convergent and informed by pragmativist "actions and views. The purpose of the study suited these philosophical positions and research design. According to Bergman (2008) states that decisions about designs, measurement, analysis and reporting all flow from a purpose. The purpose of this study requires the researcher to adapt a predominately holistic deductive paradigm in answering the research questions.

In education, the use of the pragmatic approach is centred on the discovery and use of a method that is most suitable for the research problem identified, without placing much emphasis on the arguments regarding which method is most suitable to address the problem question. A pragmatic approach, also referred to as a mixed approach, allows the researcher to utilize more than one research method or technique, simultaneously. Wouldiam James and Charles Sanders Peirce used pragmatism as a reference point for the clarification and hypothesis of concepts. It has four principles namely humanism, action**,** values**,** and experimentation.

This is an experimental pragmatism where modern science is based on experimental methods. The pragmatic aim of education is based two things which are thought and action but gives more importance to action than thoughts. Less thinking and more doing is the ideal of pragmatism. It suggests that a learner creates his own values in course of activity, that reality is still in the making and awaits its party of complexion from the future. He must be fully adjusted to his environment. The pragmatists hold the view that ideas are essentially instruments and plans of action. Therefore, students should acquire that knowledge which is helpful to them in solving the present-day problems through experimentation. Therefore, practical work would enable the learners to be able to solve the day to day life challenges.

Pragmatism holds the view that it is dynamic in nature . According to pragmatists the main focus of education to be practical so that it is valued as useful, interesting, tangible through experience and also can integrate concepts from other subjects by the learners. Therefore, the experiments of today should enable the learners to prepare for the better tommorrow as they acquire the knowledge. It stresses the priority of action over arguementation, experience over fixed principles and holds that scientific facts are based on verifiable practical integration.

3.4 Research Design

This study used mixed methods which is an approach to inquiry method of collecting both quantitative and qualitative data, integrating the two types of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. It is also worth emphasizing that using mixed methods produces complementary data for validation of the results obtained. As a result,the type of mixed approach this study used was the Convergence Model of triangulation design also referred to as the parallel convergent mixed methods approach. The convergence model of triangulation design would enable quantitative statistical results to be directly compared and contrasted with qualitative findings.

As a result, mixed-method research involves the use of both quantitative and qualitative methods in a single study. Convergence Model of triangulation design brings about cross-validation or complementary of results from qualitative and quantitative research projects is consistent with its premises particulary because researchers from this perspective are now focusd to explain what precisely converges or is complementary with respect to, for example the results of their qualitatative data and the results from experimental data. Convergence model of triangulation design is a form of mixed methods design in which the researcher converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem.

This research design allows the researcher to collect both qualitative and quantitative data almost at the same time thereafter integrates it to have an overall results interpretation. Contradictions or incongruent findings are explained or further probed in this design.In the Convergence Model of Triangulation design (Figure 3.3), qualitative and quantitative data have equal weighting as it is collected and analysed simultaneously then the results from both are compared, contrasted and merged for interpretation (Bergman, 2008).

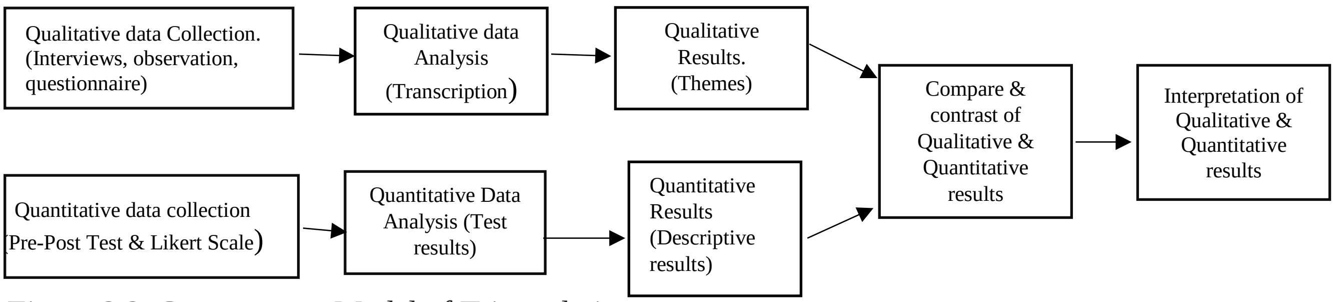

Figure 3.3: Convergence Model of Triangulation

A tringulation design convergence model was employed where both qualitative and quantitative data were collected, analysed thereafter compared and contrasted as interretation was taking place . Triangulation design coonvergence model soughts confirmation of conclusions from the convergence of findings from different methods. (Bergman, 2008). When both quantitative and qualitative methods are in a study, it provides a complete understanding of research problems than does the use of either approach alone (Plallant, 2007).

Quantitative data was collected from academic performance test using pre-test and post test results and Likert scale from both groups using either scratch program or the PowerPoint presentation on learner academic performance and attitude while qualitative data was collected by means of interviews, and observation notes during the course of the learning process. The test scores were used to measure the level of skills and knowledge achieved after the intervention. Equivalent test but testing same ability was administered as pre-test and posttest. The pretest allowed to see whether the experimental and control groups were equal in terms of knowledge whereas the posttest determined the difference in academic achievement between the experimental and control groups.

This study made use of true experimental design particularly the Solomon four group pre-test post-test design where classes were divided into groups of four where two were experiemental groups whilst the other two groups were control groups as demanded by solomon four experiemental design.Two groups received both pre-test and posttest where as the other two groups were just wrote the post-test without pre-test. The pre-test was done to assess the level at which the groups were before the interventions were done (Creswell, 2003).

The topic of learning of acid-base reactions was discussed through the scratch program in the experimental group, and through the powepoint presentation method in the control groups and another group used Teacher Based Demonstration Experiement.

The quantitative data was collected using the solomon four group design as one arm of the convergency triangulation design. The is an experiemental type where the research participants are randomly assigned to either one of the four groups that differ in whether the participants receive the treatment or not, and whether the outcome of a scratch program or PowerPoint method is measured once or twice in each group (Solomon Four Group Design, 2018). By using a pretest, a control group, and random assignment, this design reduces some internal threats to validity as There's no perfect experimental design that can eliminate all threats to internal validity on earth (Creswell, 2003).

The following structure shows the Solomon four pre-post-test group experimental group where the outcome of scratch program or Powerpoint Presentation method is measured simultaneously as it would be used in this study(Campbell, 1963 & Solomon Four Group Design, 2018).

		Time 1		Time 2
Assignment		Pre-Test	Intervention	Post-Test
Group 1	Scratch	O_1	X	O_2
Group 2	PowerPoint	O_3	X	O_4
Group 3	TBDE		X	O_5
Group 4	Non-Intervention			O_6

Where:

In Solomon four group design, the participants were randomly assigned to four different conditions as follows:-

Group 1 was a scratch program group that consisted of one hundred and twenty learners which was given an intervention with both pre-test (O_1) and post-test (O_2). This O_1 represents observations that were made during the pre-test measures. Thereafter, an intervention(X) was given to this experimental group followed by a post-test(O_2) which was teaching the group using scratch project. The O_2 represents observations that were made at post-test measures. The scratch program group was taught the concept of titration using the project from the scratch program. Post-test determined if the intervention which was teaching titration using a scratch project program affected the learners' academic performance and attitude. The outcome of interest was measured twice, once before the treatment group got the intervention which was the pre-test and once after that was the post-test. The objective was to measure the effect of the intervention.

Group 2 was a PowerPoint presentation group where a pre-test(O_3) and a post-test(O_4) were administered with an intervention in between the two tests. This group was taught using the Powerpoint Presentation method where videos on the titration concept were presented.O_3 represents the observations which were be made at pre-test measure whilst O_4 were observations made during post test for the group. The group had one and twenty learners as well.

Group 3 had one hundred and twenty learners. This was also a Teacher Based Demonstration Experiment Group which didn't take part in the pre-test. However, it was given an intervention and a post test(O_5). O_5 was the observations made at post-test measure. The intervention was teaching the class using the Teacher Based Demonstration Experiment as usual. This was to determine if the first group's performance was influenced by the pre-test including the effectiveness of the intervention instituted of learning acid base reactions using the Teacher Based Demonstration Experiment.

Group 4 was a non-interventional group with one hundred and twenty learners where it didn't have both a pre-test and intervention but just the post test(O_6). O_6 was the observation made at post test for the fourth group. Solomon four group design allowed the researcher to exert complete control over the variables and allows the reseacher to check that the pre-test did not influence the results. The outcome of interest was measured only once after the intervention took place in order to determine its effect.

3.5 Research Design Justification

The effect of virtual laboratory on learner's academic performance and attitude toward learning acid-base reactions among grade 11 learners topic could be complex and challenging. Mostly, the learning activities are designed by the teachers by following the syllabus which is sometimes overshadowed by the personal characteristics of teachers and their working enviroment context. The way a teacher delivers a lesson in class is sometimes influenced by the teacher's orientations, decisions and actions in class. On the other hand there is need to use learner centred approaches so that the learners are wholly involved in their learning process. This is one of the possible reactive effects from the participants' knowledge that they are being evaluated (Ary et al., 2010). To determine the effect of virtual laboratory on learners' attitude and academic performance, it requires the use of the convergence model triangulation research design that would allow the use of multiple data collection instruments in order to have an indepth understanding of both the teachers' and pupils' use of laboratories from the topic's practical perspective. Hence the utilisation of a project made from scratch on titration where triangulation of the data from multiple data collection instruments was used on both experimental groups and control groups. Furthermore, the Solomon four group design approach was used when collecting the quantitative data.

The use of convergent research design was viewed as better approach in terms of the credibility of the findings due to being valid and reliable which may arise from standardised methodologies besides using solomon four group design which controlled threats to validity and reliability. This followed the proposal to use a number of data collection instruments and the use of variety of triangulation techniques in sampling, data collection and analysis which was to be the strength of the research design. This was because triangualtion provided a cross data validity checks(Ary et al., 2010 & Lewis, Thornhill & Saunders, 2012) .

Triangulation techniques was critical in this research design in that they help the researcher to examine the convergence of evidence by corrobolating (or contradicting) findings from different methods and multiple sources of data (Ary et al., 2010). It was true that diffferent kinds of data sources yield different results because they are sensitive to different real world and nuances. Pallant(2007) points out that finding inconsistencies should not be viewed as a weakness in the credility of the results, but rather as offering an opportunity for deeper insights into the phenomena under study. This was a strength of the design in that it combined multiple methods in creative ways to utilise the strength of each within a single study and resulted in credible findings and a deeper understanding of acid-base reactions using a virtual laboratory.

3.6 Research Site and Setting

The study was conducted from four selected upgraded secondary schools in Mongu district, the provincial headquarters of Western Province. Mongu district had twenty-seven secondary schools where six were typically built as established secondary schools and the rest were upgraded secondary schools now referred to as upgraded secondary schools. The study was conducted on the upgraded secondary schools to enable the learners to acquire skills and knowledge using virtual laboratories to be competent in both syllabus 5070 and 5124.

3.7 Research Population

Participants of this study included all grade 11 learners at the selected Upgraded secondary schools in Mongu district offering Science 5124. The grade 11 learners were targeted as part of the study population because the preliminary data from the syllabus indicated that the sub-topic acid-base reactions would be taught in grade 11.

3.8 Study Sample

The overall study sample comprised four upgraded secondary schools where four hundred and eighty(480) grade 11 learners were to take part in the acid-base pre-test and post-test, twelve(12) learners for interviews, Likert scale attitude test and lesson observation. The Solomon four group design would be administered at each of the four upgraded secondary schools where one hundred and twenty learners would be targeted. The four groups of Solomon four group design at each upgraded secondary school had thirty(30) learners who were randomly selected and placed in four different groups. The reason for using Solomon four group design was to control the threats to the validity by using four groups.

3.9 Sampling Techniques

The study used a simple random sampling as part of quantitative methodology because the target population had a known, equal, fair and non-zero chance of being selected. This made the process to be at liberty from human judgment bias and subjectivity. The random sampling method was used as it was easy to assign numbers to the individuals (sample) and then randomly choose from those numbers through an automated process. Finally, the numbers that were chosen were the members that were included in the sample besides the data was triangulated, naturalistic and interactive (Ary et al., 2010 & Lewis, Thornhill & Saunders, 2012). This section now outlines how the participants were selected for each of the data collection instruments used. For the sampling procedure, an indikit sample calculator was used at a ninety-five (95%) percent confidence level.

However, for participants who were included in the observation and interview sessions, non-probability sampling techniques such as purposive sampling were employed as part of the qualitative research methodology. Below are the discussions of the sampling techniques used for each instrument.

Learners' attitude scale questionnaire (Likert scale) participants. Two hundred and forty learners selected using probability sampling were asked to answer the learners' attitude scale questionnaire(Likert scale) both at the pre-test stage and at the post-test stage. In the individual groups of thirty learners each, the learners were asked to respond to a Likert scale attitude questionnaire at pre-test and post-test. This means at each stage learners would be required to answer the Likert scale questionnaire to measure their attitudes. This was to determine the difference in the learners attitude towards learning acid-base reactions from the pre-test stage to post test stage.

Lesson observation participants: The study targeted the four hundred and eighty learners who were participants in the research process. The observations were made as the researcher was conducting the acid-base reaction lessons using a scratch program, PowerPoint method and Teacher Based Demonstration Experiment. The researcher conducted the lessons on titration alone hence had no need to observe other teachers but observed the learners as they learn in different groups. During lesson observation, the learners were observed on their level of interaction and participation in the lesson. The researcher was guided by the observation guide and ticked as the learners were in groups. This enabled the researcher to collect data on learners' participation and attitude towards learning acid-base reactions when both methods are used.

Acid-Base Pre-Test Participants: The two hundred and forty learners who were selected at random in the class where lesson observations were conducted wrote a pre-test. This provided the learners a level to be placed the equally before the intervention in terms of academic performance. At each of the four selected upgraded secondary schools, sixty learners were randomly assigned to two groups the experimental and control groups of thirty each. The science teachers at these schools assisted in invigilating the tests.

Acid-Base Post-Test Participants: All the four hundred and eighty learners selected using a random sampling technique in the classes where the lesson observations were conducted were eligible to write a pre-test and post-test. This provided an opportunity for learners to exhibit their understanding of acid-base chemical reactions after the intervention. At each of the four selected upgraded secondary schools, one hundred and twenty learners were randomly selected to participate in the research process. The one hundred and twenty learners were then randomly assigned to the four groups of Solomon where each group had thirty learners. This meant the four upgraded secondary schools gave four hundred and eight learners. The science teachers at these schools were assisted in the invigilation of the pre-test and post-test items as the groups were always writing at the same time. However, at post post-test, the entire four hundred and eighty learners were involved because at the pre-test stage two groups were not involved in the intervention.

Learners' interview participants: The study employed a purposive sampling of interview participants among the learners from four groups at each school. Twelve learners from each school were interviewed and they were selected as the highest, average and lowest from each of the four groups. This meant that it followed the academic performance of the learners from the post-test (Ary et al., 2010 & Lewis, Thornhil, Saunders, 2012). The average was determined by the performance of each group hence varied from one school to another. This helped to ensure that the data was balanced and reflected the opinions and experiences of the population under study as interviewees come from the drawn sample.

3.10 Research Instruments

The data collection instruments which were used in this study were the:- lesson observation schedule, learners' interviews, learners' attitude test (Likert scale) and pre-test and post-test.

3.10.1 Learners' Attitude Questionnaire (Likert Scale)

The learner's attitude scale questionnaire on the other hand was used to assess the attitude of learners towards learning acid-base reactions using the scratch program method or Powerpoint Presentation method. The learners' questionnaire was adopted by the researcher and was administered to the same learners taking part in the pre-test and post-test. Mostly the instrument was designed as an attitude test to measure the attitude of the learners towards the learning of the acid-base reactions for the four groups at each school. The learners were required to respond to the Likert scale at both pre-test and post-test for their attitudes to come out towards the teachnig methods. The learners ticked whether its SD for Strongly Disagree, D for disagre, U for Undecided, A for Agree and SA for strongly Agree.

3.10.2 Lesson Observation Guide

The study used a non-participant type of observation in which the observer's identity was reviewed to have observed the lesson. The lessons were video recorded and accompanied by observation notes. The observation included the learners' actions when learning acid-base reactions using the scratch project program and PowerPoint presentation. The video recording enabled the researcher to review the lessons at a later time or any time to transcribe the observations which enabled the researcher to complement the interpretation of observations on the learners by other teachers. The learners were given scores depending on the behaviour pattern in each lesson. The target in the observations were the learners for instance those who were co-operating by responding to questions were scoring high marks as compared to those in groups where they were rude to each other. There were six groups formed in each class to perform group activities. Therefore, both the PowerPoint presentation group and the Scratch Program group had six groups which were observed and rated using the rubric.

3.10.3 Learners' Acid-Base Reactions Test

The development of the test item was guided by the syllabi in order to gain an insight of the learners's conceptual understanding, misconceptions and learning difficulties. The test items comprised open ended test items as opposed to multiple choice questions. Halim and Osman (2010) echoes that objective items are limited in having insights of learners conceptual understanding of a concept. The test was moderated through peer review and pilot study.

3.10.4 Learners' Interviews

The focus of the interview was to determine the learners' attitude towards the teaching methods. The learners were interviewed by the research whilst a recording was made for review of the interview and for reference later on. The interview questions were meant to bring out the learners' interest towards a particular method used. The learners needed to respond to areas of interest and also the areas of concern. This allowed the study to validate the learners’ progress in rentetion rate to respond to questions. Furthermore, learners needed to bring in the suggestions of how best they can learn the concepts.

3.11 Intervention

Acid-base reactions test items were administered as pre-test to check the equivalence of the two groups, the experimental and control groups. The respective groups were met and briefed for thirty minutes on scratch program, PowerPoint Presentation method and the Teacher Based Demonstration Experiment. This meant that learners were to be aware of the importance of interacting with one another, respecting other group members’ views, sharing their views and proper time management. Probability sampling was used to get learners to respond to the attitude test and non probability sampling was used for interviews where as all the learners in both control and experimental groups were observed. Only twelve learners were sampled for interviews depending on how they performed on the post test. From each group, two were selected following high academic performance, average academic performance and low academic performance. The pre-test was administered in the first session and the last session. The follow up session where the scratch group was taught the other methods taught to the two groups and vice versa was also where interviews were conducted. At this point, the post test papers were marked and the performance of the learners was known where the learners for interviews were selected from.

At pre-post test four groups were created using Solomon four group design which was Scratch program group, PowerPoint Presentation group, Teacher Based Demonstration Experiment Group, and Non-Interventional group. The intervention was that of teaching acid-base reactions using the virtual laboratory method in seven 80-minute lessons for three to four weeks at each school to the scratch program group whilst the PowerPoint presentation group was taught acid-base reactions using the PowerPoint presentation method. The third group was taught acid-base reactions using the Teacher Based Demonstration Experiment method. The fourth group which was the Non-Interventional group was not given any pretest and had no intervention given. At the end of the interventions, all four groups of the Solomon four group design were given a post-test.

3.11.1 Intervention for the Scratch Program Group

The Solomon four group design has four groups in this study namely the scratch program group, PowerPoint presentation group, Teacher Based Demonstration Experiment and Non-

Interventional Group. Both the Scratch program group and PowerPoint presentation group were given a pre-test and an intervention where the scratch program aided the learning process in the scratch program group. The following were the steps followed for each session in the scratch program group.

Session 1: The first group of Solomon four group design was referred to as scratch program group. It was oriented on the scratch program creation and usage. The pre-test was administered in this session. The scratch program application was installed on the computers in the school. At the same time apparatus and reagents to be used in creating the scratch program were downloaded in advance. The passwords control unauthorised access to the program to reduce diffusion. The Likert scale was responded to as well in this session.

Session 2: The learners were taught acid-base reactions with an emphasis on neutralisation reactions. The titration experiment apparatus and reagents were discussed including the arrangement of the apparatus for titration.

Session 3: Creating the scratch program on titration using spikes, backdrops, downloaded reagents and apparatus. A create button was pressed allowing the scratch program to start. Backdrops give the background of the program whilst motion moves the scratch characters along the x or y direction. The sound recorder was used in recording the narration. Detailed steps are attached to Lesson Plan K in the Appendix.

Session 4: Continuation of the creation of the scratch program which had started in session three. Learners were taught how to manipulate the scratch in a manner that they would easily code the apparatus in the sprite to match the created blocks and narrations were recorded as per the attached Lesson plan in Appendix K.

Session 5: Learners display their scratch program to the class. The different groups displayed their scratch program to the class.

Session 6: Learners conduct the wet laboratory activity using the knowledge acquired from the scratch program including determining the concentration of the titrand. A post-test is administered.

Session 7: The Likert scale was responded to by the learners and the interviews were conducted with the highest, average and underperforming learners. The revision using YouTube videos was done as in the PowerPoint presentation group. The passwords were removed to enable learners to access the interventions as the research version had come to an end.

3.11.2 Intervention for PowerPoint Presentation Group

The PowerPoint presentation group was given a pre-test and thereafter, it was taught using a PowerPoint presentation embedded with videos on titration from YouTube. This was done to determine the effect of the commonly used digital platform in schools. The following were the sessions conducted:-

Session 1 : Orientation on the use of PowerPoint presentations and transfer of slides on the computers in the school computer laboratory. The researcher included passwords to access the PowerPoint presentation only when the researcher was available. Learners respond to the Likert scale questionnaire and also the pre-test administered.

Session 2: Using a PowerPoint presentation, learners were taught acid-base reactions with an emphasis on the neutralisation reaction as an attached lesson plan in Appendix K.

Session 3: Various videos on titration were displayed for learners to observe such that they had to take note of the apparatus and reagents.

Session 4: A wet laboratory activity on titration is conducted using the knowledge and skills acquired from the YouTube videos.

Session 5: Learners were taught calculations on finding the molarity of the titrand using the videos on YouTube.

Session 6: learners used the skills and knowledge from the video to calculate the concentration of the titrand from the data they had collected from the wet laboratory. A post-test was administered.

Session 7: In this session, interviews were conducted with the sampled learners and also the learners were taught acid-base reactions using the scratch program. Mistakes were rectified and the Likert scale questions were responded to by the learners. All the passwords were removed to enable learners to access the interventions.

3.11.3 Intervention for Teacher Based Demonstration Experiment Group

This group was the third group in the Solomon four group design which was not given a pre-test but was given an intervention and a post-test. This group was given an intervention by teaching acid-base reactions using the traditional method referred to as Teacher Based Demonstration Experiments(TBDE) due to limited reagents and apparatus. The sessions which were conducted were as follows:-

Session 1: Orientation on the use of the Teacher Based Demonstration Experiment methods of learning acid-base reactions. The learners are told that they will write the post-test after undergoing the teaching process. The pupils in this group didn't write the pre-test hence there was no test given.

Session 2: The teacher led the learners in the discussion of the definition of titration, the equipment and the reagents needed for the titration experiment. The use of each reagent and apparatus was discussed by the learners in groups.

Session 3: The teacher brought in charts and concrete objects of the apparatus used for titration. The students were made to identify the apparatus used during titration and then demonstrated how it was used in titration as attached lesson plan in Appendix K.

Session 4: The teacher brought in a chart of how the titration experiment was set up. Using the equipment, the teacher asked learners to demonstrate how the apparatus for titration was set. The pipette was used to measure the fixed volume of the base and poured into the conical flask. The funnel was used to pour the acid into the burette. The methyl orange indicator was added to the basic solution. The analyte was titrated into the basic solution as a rough trial. The teacher demonstrated three more trials and calculated the concentration of the acid was calculated.

Session 5: The teacher divided the class into manageable groups which depended on the availability of reagents and apparatus. The teacher distributed the worksheets for the experiment and asked the learners to perform the titration experiment.

Session 6: The learners were given a post-test where they answered the questions based on the titration experiment.

Session 7: In this session, the learners were given the same lesson using a scratch program. This enabled the learners to have a feel of the digital platform.

3.12 Data Collection Procedures

Two types of data were collected in this study, quantitative data and qualitative data. Quantitative data were collected using test results from pre- post-test on learning acid-base reactions and also the learners' attitude scale questionnaire(Likert scale). Secondly, scratch program, PowerPoint presentation and Teacher Based Demonstration Experiment of the lessons were used to determine how the methods have a bearing on the learners' performance and indicated if there was an improvement after the intervention. At the beginning of the intervention, learners were given a pre-test and at the end, a post test was administered including an attitude test at both the pre-intervention stage and post-intervention stage. The researcher asked a colleague to help with invigilation so that both the experimental and control groups were tested at the same time.

Qualitative data was collected through learners' interviews and lesson observational schedules. Video records and observational notes were made during the learning activities. The researcher alone was able to observe all the groups of learners effectively during learning activities as it was following the timetable of the classes hence the researcher was able to move from one school to another.

3.13 Data Analysis Procedures

The study used both qualitative and quantitative data analysis techniques in the analysis of data. The data collected from learners' pre-test post-test and attitude test(Likert scale) was analysed using descriptive and inferential statistics embedded in SPSS version 26. Likert scale factors were reduced using the Factor analysis techniques. The data collected from lesson observations, and interviews was analysed using qualitative data analysis(QDA) techniques. Interviews were recorded and then transcribed to form codes where themes were generated using thematic analysis. The following steps were followed when conducting thematic analysis:-

1. Familiarisation: the process of getting to know the data by reading through it as many times as possible. This involved the process of transcribing audio by reading the text taking initial notes and generally looking through the data to get familiar with it.
2. Coding: This was done by highlighting sections of the transcription which came up with shorthand labels or codes to describe the content. Every interview transcript is coded.
3. Generating themes: Codes formulated were then categorised into patterns which resulted in themes.

4. Reviewing themes: The created themes were reviewed for being useful and accurate representations of the data by comparing the data set with the themes. Themes were split, combined, and discarded and some new themes were created.
5. Defining and naming themes: this involved formulating exactly what was meant by each theme and how each theme was making the data collected understood
6. Writing up: an introduction was written on the research question which established the interview and observations.

The quantitative data collected was analysed using Statistical Package for Social Sciences (SPSS) software version 26 by adopting descriptive and inferential statistics. The normality test was conducted and found that the data was not normally distributed hence a Friedman test was done for academic performance. The findings were developed and presented in the form of tables, charts, and graphs. Academic performance research questions were answered using the Friedman test based on the academic performance results obtained from both the pre-test and post-test from each of the groups under the scratch project and also PowerPoint presentation at α-level 0.05 and confidence level 95%.

The quantitative data from the closed responses from the Likert questionnaire were coded and analysed using Statistical Package for Social Sciences(SPSS) into descriptive statistics and presented in the form of frequency tables and graphs. Factor analysis is a statistical technique used in data analysis to uncover the underlying structure or relationships among a set of variables. The quantitative aspect of the learner's performance was in two parts which were the overall classification of the learners’ performance and the learners' test score. These were analysed using spss which yielded inferential statistics.

3.14 Validity and Reliability of Pre-Test and Post-Test

Validity has been defined as,” the extent to which the instrument measures what it claimed to measure” (Ary et al.,2010, 225). In qualitative research and the recent meaning, validity is not the instrument itself but the interpretation and meaning of data or scores derived from the instrument(Ary et al., 2010).it is from this perspective that McMillan and Schumacher (2006:324) refer to validity as, “the degree of congruence between the explanation of the phenomena and the realities of the world.” Thus the validity does not travel with the instrument as a test may be valid with one population or setting but may not be valid with another.

Reliability on the other hand is the degree of consistency to which an institution measures whatever it is measuring (Ary et al, 2010) & Lewis, Thornhill & Saunders(2012:192) comment that " reliability refers to whether your data collection techniques and analytical procedures would produce consistent findings if they were repeated on another occasion or if they were replicated by a different researcher. The degree of consistency of research methodologies is affected by the following threats; participant error, participant bias, researcher error and researcher bias. These threats are more pronounced in research designs like this one based on interpretive research philosophies. Therefore, the test-retest approach was administered as a way to determine the reliability of the test items.

The Solomon Four Group design helps to control threats to the validity and reliability of the instruments as some groups are denied either a pre-test or an intervention (Solomon Four Group Design, 2018). By using a pretest, a control group, and random assignment, this design controls all internal threats to validity. The first two groups were able to control threats to internal validity while the last two groups control threats to external validity. Therefore, Solomon four group design was developed to control threats to both internal and external validity (Campbell, 1963). The equivalent forms would determine the reliability of the instruments as the same type of test would be given to the learners at the pre-test stage and a similar but equivalent test would be given at the post-test. This is an alternative form of the test from pre-test and post-test. This would show consistency of results when the test would be repeated on the same sample at a different point in time.

Therefore, to interpret data collected as valid and reliable as possible, this study piloted the developed structured data collection instruments. Triangulation in the analysis and interpretation of data from different sources of data to provide a deeper understanding of the problem, cross data validity checks and the reliability of the findings interpreted data valid and reliable.

3.15 Trustworthiness and Credibility of Observations and Interviews.

The trustworthiness of the study refers to the degree of confidence in the data, interpretation and methods used to ensure the quality of the study (Catherine et al., 2013). The criteria in this study involved credibility, audit trail, reflexibility and transferability. Firstly, the lesson observation guide and the interview guide were adopted and pre-tested on grade 11 learners at different schools in the nearby district. The findings from the trial enabled the researcher to have the instruments verified. This meant that the instruments would bring credible and trustworthy results.

The credibility of the interview guide and recordings was controlled by having peer debriefing across the process of initial coding, theme identification, theme naming and writing up. As a result, peer debriefing involvement enabled the researcher to have persistent observation and triangulation of the instruments.

As for the observations, an audit trail was maintained through a detailed and comprehensive chronological order of research activities to ensure the analytical process was coherent and transparent. As rigorous documentation of the study was maintained, the dependability of the research was upheld.

Both the interviews and observations made the researcher reflect by maintaining a reflective journal that included the researcher's views on the daily logistics of the study. It also included the impetus and rationale for all methodological decisions. This also reviewed the dependability of the study through rigorous documentation of the study activities.

In this study, the sampling technique used for the qualitative part of the research was purposive sampling which ensured that the inclusion and exclusion criteria were used to obtain a homogenous sample.

3.16 Chapter Summary

The chapter looked at the research paradigm, research design, research instruments, sampling techniques and the control of threats to validity and reliability of the instruments. The next chapter looks at the findings of the study for both attitude and academic performance as guided by the research questions.

CHAPTER 4

RESULTS OF THE STUDY

4.1 Overview

This chapter presents the findings as gathered from the responses to the research questions that guided this study. The data sets were analysed and would be presented beginning with the attitude of the learners. Thereafter, the academic performance results would be presented.

4.2 Learners' Attitude towards Learning Acid-Base Reactions

The first research question of this study was searching for answers on the differences in attitudes between the experimental groups taught using scratch program project and the control groups taught using the PowerPoint presentation method towards learning acid-base reactions. The following was the research question which was being answered at this initial part:-

1. *What are the differences in the attitude of learners taught using the scratch program and those taught using the PowerPoint presentation*?

4.2.1 Attitudes at Pre-Test.

The two hundred and forty learners' attitude responses before the intervention were analysed for both groups and presented in Table 5.1.1. The research question was being answered in this first part of the research. The pupils responded to the Likert scale questions by marking a cross(X) adjacent to the following scale in the questionnaire: 1= strongly disagree, 2= disagree, 3= undecided, 4= agree and 5= strongly agree.

Table 4.1

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
I like titration experiment lessons	1.37	.506	240
I think titration is important to understand acid-base reactions	1.51	.517	240
I can perform titration experiments	1.37	.505	240
I ask questions on titration whenever acid-base reactions are presented	3.80	.889	240
I think the scratch program/PowerPoint presentation method is not a good strategy for learning acid-base reactions	1.49	.506	240
I am excited about activities that involve scratch program/PowerPoint on acid-base reactions	1.54	.521	240
I think other topics should be taught using the scratch program/PowerPoint presentation method	1.50	.517	240
I think the scratch program/PowerPoint presentation method is not beneficial to me	4.31	.749	240
I am excited about scratch program/PowerPoint Presentation methods used in teaching acid-base reactions	1.53	.516	240
I feel delighted learning acid-base reactions using the scratch program/PowerPoint Presentation method	1.52	.506	240
I like interacting with others when learning acid-base reactions	1.36	.498	240
I participate actively in acid-base reactions lessons	1.34	.504	240
I lost interest in acid-base reactions lessons	4.51	.501	240

Table 4.1 depicts the means of the variables. Most of the means of the variables are low and it's being attributed to having no intervention as this is the Pre-Test stage. The lack of intervention resulted in the means being low for most of the variables.

4.2.2 Factor Analysis

Factor analysis is a data reduction technique. It is unique in statistics because it doesn't state which group is significant to the other but It takes into account a large set of variables and looks for a way the data may be reduced or summarised using a smaller set of factors or components. It is up to the researcher to determine the number of factors that he/she considers best describe the underlying relationship among the variables. This involves balancing two conflicting needs: the need to find a simple solution with as few factors as possible; and the need to explain as much of the variance in the original data set as possible (Pallant, 2007). Tabachnick and Fidell (2007) recommend that researchers adopt an exploratory approach, experimenting with different numbers of factors until a satisfactory solution is found. In this study, exploratory factor analysis was used as an early stage of research to gather information about (explore) the interrelationships among a set of variables. It does this by looking for clumps or groups among the intercorrelations of a set variable. Factor analysis was used to reduce a large number of related variables to a more manageable number, before using them in other analyses in this case the Mann Witney U test. Several techniques can be used to assist in the decision concerning the number of factors to retain:

1. Kaiser's criterion;
2. Scree test; and
3. Parallel analysis.

To perform an effective factor analysis, a sample size of more than one hundred and fifty cases is better. One of the most commonly used techniques is known as Kaiser's criterion, or the eigenvalue rule. Using this rule, only factors with an eigenvalue of 1.0 or more are retained for further investigation (Pallant, 2007). Below are the Kaiser-Meyer-Olkin(KMO) test and scree plot which were done for the factors in the Likert scale to be reduced.

4.2.3 Kaiser-Meyer-Olkin (KMO) Test

Kaiser-Meyer-Olkin (KMO) Test and Bartlett's Test of Sphericity are two common statistical tests used in the context of factor analysis to assess the appropriateness of the data for factor analysis and to evaluate whether the observed variables in a dataset are suitable for extracting underlying factors.

Table 4.2

KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.711
Bartlett's Test of Sphericity	Approx. Chi-Square	5691.993
	Df	78
	Sig.	.000

Table 4.2 shows two tests that indicate the suitability of your data for structure detection. It is a measure of sampling adequacy is a statistic that indicates the proportion of variance in the variables that might be caused by some underlying factors. KMO value varies from 0 to 1. The KMO values between 0.8 to 1.0 indicate that the sampling is adequate. KMO values between 0.7 to 0.79 are middling and values between 0.6 to 0.69 are mediocre. However, KMO values

less than 0.6 indicate the sample is not adequate. A KMO value over 0.5 and a significance level for Bartlett's test below 0.05 suggests there is a substantial correlation in the data. The correlation matrix Table 4.2 shows that there is a positive correlation between the various factors in the matrix. On the KMO and Bartlett's test Table 4.2, the significant level is 0.000 which is less than 0.05. This determines whether the correlation matrix is the same as the identity matrix. The null hypothesis in the KMO and Bartlett's test is that there is no correlation between the item's correlation and the identity matrix. Therefore, the null hypothesis is rejected as the items in the matrix correlate.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.711 which is higher than 0.7. This means that there are two underlying dimensions which are the teaching methods and that the factor analysis could be conducted.

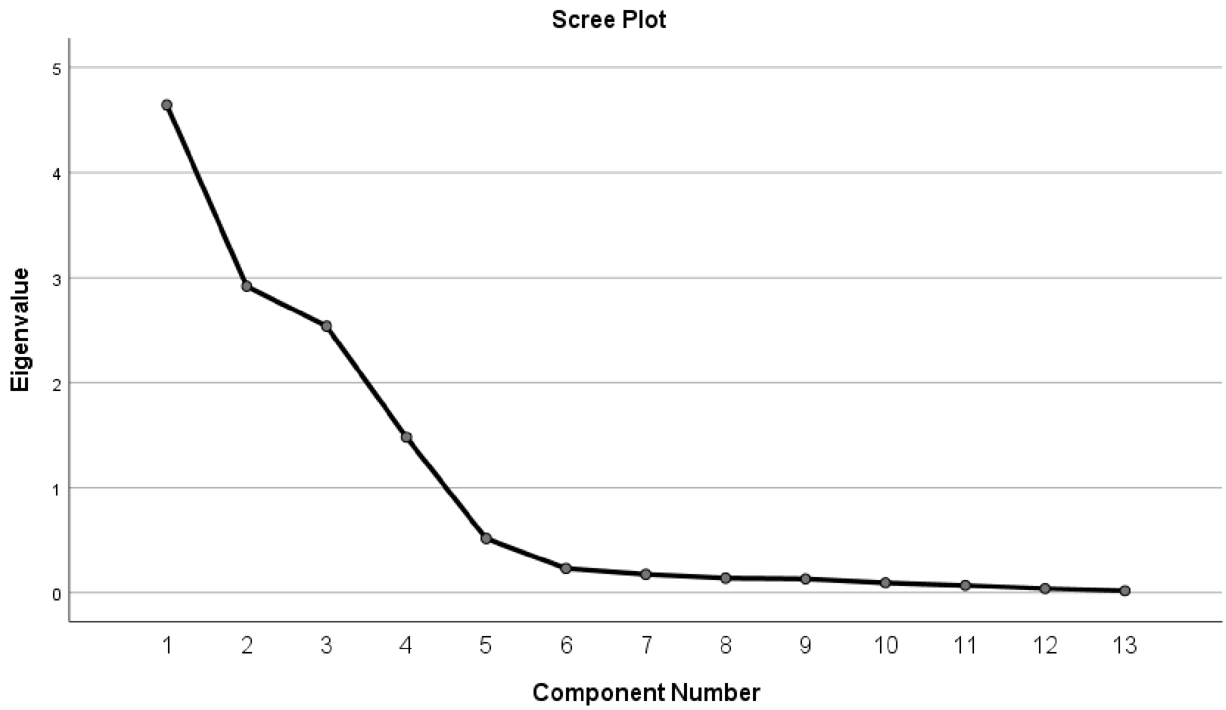

Figure 4.1**:** Scree Plot

Another approach that can be used is Catell's scree test (Catell 1966). This involves plotting each of the eigenvalues of the factors and inspecting the plot to find a point at which the shape of the curve changes direction and becomes horizontal. Catell recommends retaining all factors above the elbow, or break in the plot, as these factors contribute the most to the explanation of the variance in the data set. A scree plot shows the eigenvalues on the y-axis and the number of factors on the x-axis. It always displays a downward curve. The eigenvalue of a factor represents the amount of the total variance explained by that factor. Pallant (2007) recommends retaining all factors above the elbow, or break in the plot, as these factors contribute the most to the explanation of the variance in the data set. The point where the slope of the curve is levelling off (the elbow) indicates the number of factors that should be generated by the analysis. Eigenvalues are a measure of the amount of variance accounted for by a factor and so they can be useful in determining the number of factors that are needed to be extracted. In a scree plot, simply plot the eigenvalues for all of the factors and then look to see where it drops off sharply. The scree plot has four factors which are above the eigenvalue of 1.

4.2.4 Total Variance Explained

Table 4.3 shows the initial Eigenvalues taking note of the eigenvalues greater than 1. In this case, only four components have total initial eigenvalues greater than 1. Those four components explain 89.067% of the variance. Therefore, the conclusion is that there are only four factors extracted.

Table 4: 3

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.643	35.716	35.716	3.367	25.900	25.900
2	2.917	22.440	58.157	3.005	23.116	49.016
3	2.538	19.522	77.678	2.761	21.238	70.254
4	1.480	11.388	89.067	2.446	18.813	89.067
5	.516	3.970	93.037			
6	.231	1.779	94.816			
7	.176	1.351	96.167			
8	.140	1.078	97.244			
9	.133	1.021	98.266			
10	.096	.738	99.003			
11	.070	.540	99.543			
12	.040	.309	99.852			
13	.019	.148	100.000			

Extraction Method: Principal Component Analysis.

4.2.5 Component (Factor) Matrix

Table 4.4 shows the loadings of the eight variables on the four factors extracted. The higher the absolute value of the loading, the more the factor contributes to the variable. The negative values in Table 4.4 represent loadings that are less than 0.5, which makes all the loadings less than 0.5 suppressed.

Table: 4.4

Component Transformation Matrix

Component	1	2	3	4
1	.727	-.466	-.032	.503
2	-.229	-.174	.930	.228
3	.363	.867	.181	.289
4	-.536	.030	-.318	.781

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

4.2.6 Rotated Component Matrix

This is the linear transformation of the original component matrix resulting in a new set of vectors that are either orthogonal (uncorrelated) or oblique (correlated) factor solutions. Tabachnick and Fidell (2007) state that orthogonal rotation results in solutions that are easier to interpret and report. However, they do require the researcher to assume (usually incorrectly) that the underlying constructs are independent (not correlated). Oblique approaches allow for the factors to be correlated but they are more difficult to interpret, describe and report. The rotated component matrix contains estimates of the correlations between each of the variables and the estimated components. The idea of rotation is to reduce the number of factors on which the variables under investigation have high loadings.

From Table 4.5, the factors were rotated and only four components were brought out. The factor with the highest loadings subdues other factors and these can be renamed according to the factors which have been compounded there.

Table 4.5

Rotated Component Matrix

	Component			
	1	2	3	4
I like interacting with others when learning acid-base reactions	.877			
I can perform titration experiments	.871			
I think other topics should be taught using the scratch program/PPT presentation method	-.759			
I am excited about scratch program/PowerPoint presentation methods used in teaching acid-base reactions	.622			
I lost interest in acid-base reactions lessons.		.964		
I think titration is important to understand acid-base reactions.		-.932		
I think the scratch program/PPT presentation method is not beneficial to me.		.636		.509
I think the scratch program/PPT method is not a good strategy for learning acid-base reactions			.952	
I am excited about activities that involve scratch programs/PPTs on acid-base reactions.			-.934	
I participate actively in acid-base reactions lessons.			.714	
I ask questions on titration whenever acid-base reactions are presented.				.935
I feel delighted learning acid-base reactions using the scratch program/PowerPoint presentation method	-.515			-.750
I like titration experiment lessons		.581		-.652

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

The thirteen factors were correlated and rotated into four components. For instance, component one had factors 11, 03, 07 and 09 with factor 11 stating that,” I like interacting with others when learning acid-base reactions having the highest loading of 877. This can be renamed as ‘effective interactions among learners.’

The second component had factors 13, 02, and 08 which stated that ‘I lost interest in acid-base reaction lessons having the loading of 964. This component can be renamed as a scratch program/PowerPoint presentation that motivates learners to participate in the lessons.

The third component of factors were three which were factor number 05,06 and number 12 which stated that ‘ am excited with activities that involve scratch program/PowerPoint presentation on acid-base reactions’ having the highest loading of 509. Therefore, this could be renamed as ‘scratch program/PowerPoint are good attitudinal enhancers on learning acid-base reactions’

The four components had three factors equally with the highest having a loading of 935 which was I participate actively in acid-base reactions lessons. The factors that constituted this were factor number 04, 10 and 01. This component can be renamed as ‘Good participatory teaching approaches to learning acid-base reactions’.

4.2.7 Test of Normality

A test of normality is a statistical procedure used to assess whether a dataset follows a normal distribution. The normal distribution, also known as the Gaussian distribution or bell curve, is characterized by a symmetrical, bell-shaped curve with specific properties, such as a mean (average) at the centre, a median and mode that are also at the centre, and a specific pattern of tails.

Testing for normality is important in statistics because many statistical methods and tests assume that the data come from a normal distribution. If your data significantly deviates from normality, it may affect the validity of these assumptions and the results of your analysis. The normality test has got two tests namely the Shapiro-Wilk Test and the Kolmogorov-Smirnov test.

The Shapiro-Wilk test is a widely used parametric test for assessing normality. It tests the null hypothesis that a dataset comes from a normally distributed population. If the p-value obtained from the test is less than a chosen significance level (e.g., 0.05), you may reject the null hypothesis and conclude that the data is not normally distributed.

Keep in mind that the Shapiro-Wilk test is sensitive to sample size. For large samples, even minor departures from normality can lead to a significant result. Therefore, it's essential to consider both the p-value and the visual inspection of the data.

The Kolmogorov-Smirnov test is another test for normality that compares the Empirical Cumulative Distribution Function (ECDF) of the data to the cumulative distribution function of a normal distribution. Like the Shapiro-Wilk test, if the p-value is less than the chosen significance level, you may reject the null hypothesis of normality.

Table 4.6

Test of normality

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Different groups	.223	360	.000	.793	360	.000
a. Lilliefors Significance Correction						

The significance of the p-value in the Shapiro-Wilk test was 0.000 which was less than 0.05, this means the null hypothesis was rejected as it's a non-normal distribution. The conclusion is that the variables are not normally distributed. This means that the data's distribution significantly differs from a bell-shaped normal distribution. Therefore, a non-parametric analysis would be conducted. Thereafter, the Mann-Whitney U test as a non-parametric test was used.

4.2.7 Mann-Whitney U Test

The Mann-Whitney U test, also known as the Mann-Whitney-Wilcoxon test or the Wilcoxon rank-sum test, is a non-parametric statistical test used to determine if there is a significant difference between two independent groups based on their ranks (orderings) of values. It is commonly used when the assumptions for a parametric test like the t-test (e.g., normal distribution of data, homogeneity of variances) are not met, or when dealing with ordinal or skewed data. If the p-value is less than or equal to the significance level ($p<0.05$), the decision is to reject the null hypothesis. However, when the p-value is greater than the significance level ($p>0.05$), the decision is to retain the null hypothesis.

Table 4.7:

Mann-Whitney U Test Ranks

Ranks				
	Different groups	N	Mean Rank	Sum of Ranks
Effective interaction among learners	Scratch Project	120	103.50	12420.00
	PowerPoint	120	137.50	16500.00
	Total	240		
Motivates the learners	Scratch Project	120	129.00	15480.00
	PowerPoint	120	112.00	13440.00
	Total	240		
Good attitudes exhibited	Scratch Project	120	137.50	16500.00
	PowerPoint	120	103.50	12420.00
	Total	240		
Active participation	Scratch Project	120	146.76	17611.50
	PowerPoint	120	94.24	11308.50
	Total	240		

Test Statistics

	Effective participation among learners	Motivates the learners	Good attitudes exhibited	Active participation
Mann-Whitney U	3333.000	6431.000	6454.000	6598.000
Wilcoxon W	10593.000	13691.000	13714.000	13858.000
Z	-1.530	-1.519	-1.446	-1.222
Asymp. Sig. (2-tailed)	.120	.129	.148	.222
a. Grouping Variable: Different groups				

The total number of participants was two hundred and forty segregated as one hundred and twenty for the scratch project group and another one hundred and twenty for the PowerPoint Presentation group. The mean ranks of the participants were varying with each of the factor to be analysed. At other times, the mean rank for Scratch Project was higher than the mean rank for PowerPoint Presentation group. This means that the difference in attitude was lack of an intervention on the part of the learners. The learners were not taught as yet hence one group could have a higher rank as compared to the other on one factor whilst on other factors another group was higher in terms of mean ranks.

The p value is a probability that measures the evidence against the null hypothesis. The statistically significant test result is that the p value is greater than the alpha value of 0.05 ($P<0.05$). The null hypothesis is retained for all the factors. Therefore, there was no significant statistical difference between the two groups as their attitudes were rated to be the same at pre-test ($u=3333$, $p=0.120$). The attitude of the learners was the same at pre-test level because the teaching methods of PowerPoint presentation and scratch program were not yet introduced.

4.2.8 Attitudes at Post Test

Table 5.3 shows the results as analysed for the two hundred and forty learners. The learners were given a questionnaire to respond at post-test stage to determine if there was a change of attitude from the attitude exhibited at pre-test stage. The learners were to cross in the box which was beside their feelings towards the various questions. For instance, if the learner felt he/she agreed to the question then a cross is placed on agreeing box. The Table 5.3 shows the results derived from the responses of the learners. The learners' attitude would be determined by their responses where if the learners responded affirmatively to the questions, their attitude would be considered as good and if the responses were negative, the learners' attitude would be considered as unsatisfactory.

Table 4.8

Descriptive statistics

	Mean	Std. Deviation	Analysis N
I like titration experiment lessons	3.86	.988	240
I think titration is important to understand acid-base reactions	3.41	.980	240
I can perform titration experiments	3.71	1.120	240
I ask questions on titration whenever acid-base reactions are presented	3.78	.881	240
I think the scratch program/PowerPoint method is not a good strategy for learning acid-base reactions	2.14	1.340	240
I am excited about activities that involve scratch programs/PowerPoint on acid-base reactions	4.12	1.079	240
I think other topics should be taught using the scratch program/PowerPoint presentation method	3.89	.902	240
I think the scratch program/PowerPoint presentation method is not beneficial to me	2.03	1.331	240
I am excited about scratch program/PowerPoint Presentation methods used in teaching acid-base reactions	3.85	.939	240
I feel delighted learning acid-base reactions using the scratch program/PowerPoint Presentation method	2.76	1.473	240
I like interacting with others when learning acid-base reactions	3.50	1.654	240
I participate actively in acid-base reactions lessons	4.53	.500	240
I lost interest in acid-base reactions lessons	1.48	.563	240

Table 4.9 of descriptive statistics indicates that the mean has risen as compared to the mean at the pre-test. Therefore, it shows that the attitude of the learners has increased because of the interventions which were done on two groups which are the different teaching methods. The experimental group used the scratch program as a teaching method whereas the control group had a PowerPoint presentation as the intervention. Because of the intervention, the means at various questions were raised.

4.2.9 Test of Normality

The data which was collected at the Post-Test was tested if it was normally distributed using the Shapiro-Wilk test of normality. Table 4.9 shows the test of normality at PostTest for attitude exhibited by the learners:-

Table 4.9

Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Different groups	.342	360	.000	.636	360	.000
a. Lilliefors Significance Correction						

The test of normality tests the null hypothesis for the normally distributed data. Table 4.9 shows that the p-value is smaller than the alpha value of 0.05. Therefore, there is a significant deviation of the data from being normally distributed. As a result, the data is not normally distributed hence the null hypothesis is rejected. Mann Witney U test was conducted.

4.2.10 Mann Witney U Test

The Mann-Witney U test was conducted because the data when it was tested for normality, had shown that it was not normally distributed hence the need to use a non-parametric test equivalent to t test. This made the researcher use Mann Witney U test. Table 4.11 shows the Mann-Whitney U Test.

Table 4.10

Mann Whitney U Test Ranks

Ranks				
	Different groups	N	Mean Rank	Sum of Ranks
Effective interaction among learners	SCRATCH	120	152.72	18327.00
	POWERPOINT	120	88.28	10593.00
	Total	240		
Motivates the learners	SCRATCH	120	126.91	15229.00
	POWERPOINT	120	114.09	13691.00
	Total	240		
Good attitudes exhibited	SCRATCH	120	126.72	15206.00
	POWERPOINT	120	114.28	13714.00
	Total	240		
Active participation	SCRATCH	120	125.52	15062.00
	POWERPOINT	120	115.48	13858.00
	Total	240		

Test statistics

	Effective interaction among learners	Motivates learners	Good attitudes exhibited	Active participation
Mann-Whitney U	5658.000	4800.000	5063.000	4533.500
Wilcoxon W	12918.000	12060.000	12323.000	11793.500
Z	-3.490	-5.160	-4.580	-5.865
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

The mean ranks at the post-test were higher for the scratch program group as compared to the PowerPoint presentation group. This was as a result of the intervention the two groups underwent. The scratch group was taught acid-base reaction using the scratch program whilst the PowerPoint group was taught using the PowerPoint presentation. The higher mean ranks suggest that the learners' attitude had improved much more under the scratch program as compared to the PowerPoint presentations. As a result, it can be concluded that both teaching methods bring about an increased motivation which in turn raises the attitude of learners towards learning acid-base reactions. However, the scratch program when used in teaching increases the learners' attitude higher than the PowerPoint Presentation method. There was effective interaction among the learners when learning using scratch compared to the group which used PowerPoint presentation method.

Attitudes at the Post-test were measured by a null hypothesis which stated that there was no statistical difference in attitude expressed by the learners taught using different methods in this case those taught by scratch project and those taught by PowerPoint Presentation methods. The p-value was smaller than the alpha value ($0.000<0.05$) therefore, the null hypothesis was rejected ($U= 5160$, $p=0.000$). In this case, the difference in attitude of the learners towards learning acid-base reactions, particularly titration was brought about by the teaching of the said topic to two different groups using two different teaching approaches. In this case, the group that was taught using scratch project expressed a better attitude disposition toward learning acid-base reactions as compared to the group that was taught using PowerPoint presentation. Therefore, the difference in attitude expressed by the two groups was because of the difference in the type of intervention that was used to teach the different groups.

4.2 Attitudes expressed in Interviews

This section looked at the attitude expressed by the learners which answered to the research question below:-

What are the differences in the attitude of learners taught using the scratch program and those taught using the PowerPoint presentation?

The interview extracts from learners from the experimental group was coded and categorised as follows:-

Codes	**Categories**
Exciting experience	Enjoyed learning titration
Enjoyable	
Enjoyable experience	
Not bored	Interesting program
Continue coding	
Capable of solving	
Not tired	

The categories above were grouped to form a theme which in this case was *enjoyed learning using scratch program as it is an interesting program.* The theory made was that *learners enjoyed learning titration using the scratch program because it was an interesting program.*

The first theme generated was that *" enjoyed learning using scratch program as it was an interesting program*." Therefore, the learners who were taught acid-base reactions had better attitudes and performed better academically post-intervention because the scratch program which was used in the process of teaching the learners was interesting. The interest made the learners to be motivated such that they performed very well academically. The learners never got tired or bored because it was an interesting program. This made the learners continue using codes to attach narrations and apparatus to the scratch program. When learners are interested, they always push they continue learning. Thus the learners enjoyed learning titration using the scratch program where they were capable of solving molarality calculations when the volume of both the titrate and the titrant was obtained including the already known concentration of the base. Learners enjoyed learning using the scratch program because there were repetitions that could be played. The learners were able to play back a concept to recap what it meant if it was misunderstood.

Learners were asked whether they liked the methods of teaching acid-base reactions in this case titration. The learners interviewed brought out two common aspects such as enjoyable learning acid-base reactions using games from the Scratch program or watching videos on YouTube using PowerPoint presentation and that learners were participating actively to correctly perform the titration experiments.

The learners being interviewed were asked to describe their experience when using a Scratch program or PowerPoint presentation method. The interviewees gave the responses that it was enjoyable to code apparatus using the Scratch program to produce motional videos whilst those from the PowerPoint presentation stated that it was very nice to watch on YouTube how titration was being done. The learners enjoyed coding and watching how titration was done using the Scratch program hence they were motivated to continue coding whenever they were finished with one. Furthermore, the interviewees said that the learners taught each other how to code the apparatus to produce videos as compared to the learners always getting it from the teacher. The lessons were enjoyable and entertaining hence the majority of the learners were able to grasp the concepts. Below is an extract from one of the interviews as responded to by E2:-.

It was an exciting experience in which I had to learn titration using the Scratch Program method. It was enjoyable as I was not getting tired and bored and the coding exercises were nice. It seems as if hmmm you are playing a game whilst you are solving problems of titration. When I download and code an apparatus using the Scratch program, I want to continue coding with narration hence it was encouraging me to always go to complete the exercise. I think this time am capable of solving any problem related to titration practically which I can face because I have learned a lot of tricks from the scratch program. It was an enjoyable experience which I have had with the scratch program.

The interview extracts from learners was coded and categorised as below:-

codes	**categories**
Good presentations	Nice presentations
Enjoyable	
Encouraged practice	Easy to follow
Able to follow rules	

The second theme generated was that there were *nice and easy-to-follow presentations*. The learners enjoyed watching videos and playing back to gain insights of the concepts was the main cause of their being able to follow the program well. In scratch, they used games that they created hence presented to the class. The learners were able to learn skills by following the creation of the scratch program. As the learners were in groups, they were able to control one another and they followed the program with easy. The learners were able to follow the concepts concerning the conducting of titration using the video displayed. Therefore, the theory derived was that *PowerPoint presentation was a nice and easy-to-follow teaching approach*. These views indicated that the learners enjoyed learning acid-base reactions using the PowerPoint presentation methods because of being collaborative. One learner C1 from the PowerPoint presentation stated that:-

…I enjoyed hmmm the presentations, especially on the YouTube videos which were teaching us how to conduct titration experiments such that when we were doing it on our own we were able to follow the rules well. I was encouraged to do more practice on titration experiments so that

I could solve problems related to acid-base reactions. Hmmm, the videos were helpful as various ways of getting the correct answers on titration were displayed hence it was enjoyable to me….

Among the questions, the researcher asked the learners was to explain how they were involved and participated in the learning process to titrate the acid-base reactions as in neutralisation reactions. The interviewers indicated that the learners were wholly involved in the learning process as it was learner-centred. The learners were put in small groups such that they were able to teach one another and the teacher was there to guide them when they got stuck. The learners also stated that they participated actively in the learning process as the scratch games and videos were played over and over again to have a full understanding. The extraction from the interview from E1 at another school was as follows:-

Hmmmm we don't usually use computers to learn except when it's computer studies hence it was really good to use them to learn titration. All my friends wanted to play the scratch program videos on the computer to determine how titration is done hence each member of the group participated in viewing titration expriements using the Scratch Program app on the computers. The learners were involved in the lessons so much that it made them continue solving problems related to titration even when it was not the period for chemistry as long as the computer lab was free.

The codes and categories from the interview extracts were derived as below:-

Code	**Categories**
Good to use	Active
Play to learn	
participate	Participate
Continued solving	
Whollyinvolved	

Therefore, the third theme which emerged was that of *learners' active participation.* This was because the learners encouraged one another in the groups to continue solving problems using the computer. As from the above response, the learners had good experiences with both the Scratch project and also the PowerPoint presentation. In both methods of learning, learners were able to actively participate and are involved in the lessons because the first one was the introduction of the ICT gadgets and the second one was the motivation to continue working on their work based on the games and videos were arousing interest in them as evidenced by their statements from the interviews. However, the scratch program had a high participation rate because the learners were coding and each learner in the group was interested in touching the apparatus. As a result, it made the learners be able to be involved wholly in the lessons as compared to the group under PowerPoint presentation who were mostly watching videos and practicing what they had watched. The second learner captured as C4 from the Powerpoint Presentation method as a control group responded as follows:-,

> *I participated actively in the lessons by watching the videos and then trying to titrate in acid-base reactions on my own by following the rules learnt from both the texts and videos. I have been performing titration experiments very well. I also involved others and the teacher where I got stuck. I watched the videos to determine where exactly I was going wrong whenever I failed to correctly titrate to the endpoint. Even my fellow learners also helped me when I was not able to correctly calculate the titrant and the titrate.*

It is generally believed that learners understand fully by doing and being involved in the lesson. This is the reason why the learners were put in small groups of six each on a computer with the Scratch program and PowerPoint presentation methods. This enabled the learners to work in groups effectively such that they were able to consult one another and correctly balance the chemical equations. Most of the learners were able to correctly titrate to the endpoint during and after the process.

4.3 Results of Lesson Observations

A rubric was used to observe the learners' attitudes and participation as the implementation of the intervention was taking place. The rubric intended to measure the attitudes and participation of the learners in the Scratch program and PowerPoint Presentation Slide. The highest score was five(5) and the lowest score was One(1). The Researcher and his co-researchers awarded observatory marks independently in collaboration with the laid down guidelines and then discussed the correct mark for the group if there were any disparities between them. The researcher used the rubric as a guide to show the behaviour of the learners in various sessions as shown below:-

Table 4.11:

The rubric of lesson observations result

CRITERIA	GROUPS	SESSION 2	SESSION 3	SESSION 4	SESSION5	SESSION 6
ATTITUDE AND PARTICIPATION	SCRATCH GROUP	2	3	3	5	5
	POWERPOINT	1	2	2	3	3
	TBDE	1	1	2	2	3

In the second session of learning, learners from the Scratch Program method scored two points as they rarely demonstrated and responded to each other. From the rubric, any group that rarely demonstrated and responded to each other scored two points. Therefore, when the scratch program group met, the group scored two points where the learners did not showing the desire to demonstrate to each other the balancing of the chemical equations except a feel in the groups. This meant that the learners had a poor attitude and participation among themselves. However, the Scratch program group had better participation and attitude as compared to the PowerPoint presentation and Teacher Based demonstration Experiment (TBDE) group despite exhibiting poor behavior with hesitance demonstrations and poor participation. This could be attributed to the lack of competence in the handling of the gadgets and the software application involved on the first day.

On the other hand, the learners in PowerPoint presentation and Teacher Based Demonstration Experiment group scored one point because the members of the groups typically hesitating to demonstrate to each other under participation whereas, on attitude, the groups rarely demonstrating to each other. The PowerPoint presentation group had one point despite exhibiting a little bit of cooperation with fellow learners and responding occasionally to questions. Therefore, on participation and attitude on the first day, the Scratch group taught group was observed to have better attitudes as compared to the group taught using the PowerPoint presentation.

Furthermore, in the third session, the learners' participation and attitude had increased a lot like the Scratch program group had three points. The group's members consistently demonstrated to each other and responded to questions appropriately whereas the other two groups of PowerPoint presentation groups had two points where learners were demonstrating to each other including good responses with co-operation from fellow learners. The Teacher Based Demonstration group had one point learners’s responses including body language were not consistently respectful and rarely demonstrated including responding to each other's questions. Therefore, at this stage, the group that was using the Scratch program had high participation and attitude rating as compared to the group that was using PowerPoint presentations.

In the last session, the Scratch program group scored five points each as they had gained more interest in creating and watching scratch program games which increased participation and attitude. In this group, learners were able to demonstrate to each other with appropriate questions. On the other hand, the group that was using PowerPoint presentation and Teacher Based Demonstration Experiment groups had three points each as they demonstrated to each other with appropriate body language including responses that were respectiful. Based on the above evidence, therefore, the group that was using the Scratch program had a high rate of participation and attitude as compared to the groups that were using PowerPoint presentation and Teacher Based Demonstration Experiment group. The conclusion from the lesson observations was that the Scratch program group had learners who were highly motivated hence the high rate of participation and attitude.

4.4 Academic Performance Test Results

Research question number two(2) was intended to find out the difference in academic performance in titration experiments between the learners who were taught using the Scratch program and those taught using PowerPoint presentations. The following was the research question:-

1. *What are the differences in academic performance between learners taught acid-base reactions using the scratch program and those taught using the PowerPoint presentation method?*

4.4.1 Academic Performance at Pre-Test

The two hundred and forty learners were involved in the pre-test. The researcher formed four groups of thirty learners at each school. However, only sixty learners at each of the four upgraded secondary schools were given pre-tests in line with the tenets of Solomon's four research designs. The other two groups were not pre-tested as it was following the Solomon four principles. Therefore, in pre-test only two groups were tested which were the scratch program group and PowerPoint presentation group.

4.4.2 Test of Normality for Pre-Test

The collected data for both groups on the academic performance test were analyzed using SPSS where a normality test and Friedman test were used. A normality test was conducted using the Shapiro-Wilk test of normality. The Shapiro-Wilk test examines if a variable is normally distributed in some populations. In this test, the interpretation is that when the p-value is less than 0.05, then the null hypothesis is rejected. This means that the obtained variables are not normally distributed. However, if the p-value is greater than 0.05, the null hypothesis is retained. This means that the obtained values are normally distributed. This means that when plotted on a graph, it brings a bell-shaped graph where the majority of the learners are the middle with those who are performing low and high on either side of the graph. Table 4.12 below shows the results of the test for normality test at pre-test.

Table 4.12

Test of normality for Pre-Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SCRATCH PROGRAM	.222	120	.000	.892	120	.000
POWERPOINT	.237	120	.000	.894	120	.000
a. Lilliefors Significance Correction						

The significance of the p-value in the Shapiro-Wilk test was 0.000 which was less than 0.05, this means the null hypothesis is rejected as it's a non-normal distribution. The conclusion is that the variables obtained at the pre-test are not normally distributed. The bell-shaped graph cannot be obtained from the results obtained at pre-test. Since it was a non-normal distribution, the Friedman test would determine the significant difference between the two mean ranks of the scratch group and the PowerPoint Presentation method.

Table 4.13:

Descriptive Statistics

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
Scratch Program	120	7.75	4.668	0	20
PowerPoint Presentation	120	7.58	5.225	0	20

The total number of learners was two hundred and forty (240) and each group(N=30) from each of the four schools had thirty learners. The mean for the PowerPoint presentation group was 7.58 whereas the first Scratch program Group named scratch program group had a mean of 7.78 making the mean difference between the Scratch Program group and PowerPoint group to have a difference of 0.17. When the means of the pretest scores of the two groups from Solomon's four group design were analysed using spss, their results reviewed that there was no statistically significant difference between the mean scores of the Scratch program group and that of the PowerPoint presentation group. The standard deviation shows how spread the data was from the mean. It determined how far it deviated from the mean. For instance, the PowerPoint presentation group had a standard deviation of 4.668 which meant that the scores were not spread further apart from each other. This indicated that some learners got slightly higher marks while others got slightly lower marks, whereas the standard deviation for the scratch program group was 4.668 depicting that the scores were close to each other indicating that the majority of the learners had marks close to each other meaning the difference between the lowest and the highest was small.

The implication was that both the scratch program group and the PowerPoint presentation group had no significant statistical difference at the Pre-test level despite the group under the Powerpoint Presentation method having a lower mean as compared to the scratch program group at the pre-test stage. Therefore, any changes in the posttest results can be attributed to the difference in the teaching methods and techniques as depicted by both the group statistics and the Fried Test Table 4.14 below:-

4.4.3 Friedman Test

The Friedman test is a non-parametric alternative to one-way ANOVA with repeated measures. This test is used when the results in terms of scores obtained are not normally distributed. As a result, the Friedman test is a non-parametric test for analysing randomised complete block designs. Therefore, the Friedman test compares the mean ranks between the related groups and indicates how the groups differed. It is an extension of the sign test when there may be more than two treatments. The Friedman test assumes that there are k experimental treatments (K>2). It is an alternative to the repeated measures ANOVA, it is used to detect differences in treatments across multiple test attempts**.**

To determine whether any of the differences between medians are statistically significant, the p-value was compared to the significant level to have the null hypothesis assessed. The null hypothesis stated that the population medians are all equal. If the p-value was less than or equal to the significance value, the null hypothesis would be rejected and concluded that not all the population medians were equal.

The Friedman test was used to test for differences between groups when the dependent variable being measured was ordinal. It could also be used for continuous data that had violated the assumptions necessary to run the one way ANOVA with repeated measures such as the data that had marked deviations from normality.

Table 4.14

Friedman Test at Pre-Test

Ranks	
	Mean Rank
SCRATCH PROGRAM	1.51
POWERPOINT PRESENTATION	1.49

Test Statistics[a]	
N	120
Chi-Square	.084
df	1
Asymp. Sig.	.772
a. Friedman Test	

When the mean ranks were compared, the Scratch program group had the highest mean rank at 1.51 compared to the PowerPoint presentation group at 1.49. The difference in mean between the two groups was 0.02 which was quite insignificant. Therefore, in pre-test, the two groups were at the same academic performance level. In this regard, the two distinct groups at the pre-test were at the same academic performance level.

Table 4.14 indicates the test statistics of the scratch program and PowerPoint presentation groups. Both Scratch program and PowerPoint presentation groups had a p value of 0.772 which was greater than 0.05 ($p>0.05$). As a result, the null hypothesis was retained which stated that there was no significant statistical difference in academic performance between the two independent groups. Therefore, at pre-test there was no significant statistical difference in academic performance between the two groups. At pre-intervention, the two groups began at the same level in terms of knowledge acquisition.

Table 4.14 shows the Friedman test which is a non-parametric test for finding differences in treatments across multiple groups. This test is primarily used to examine whether the difference between multiple treatment of the groups. Under the pre-test, the null hypothesis is retained if the $p>0.05$ and rejected when its $p<0.05$. Therefore, the p-value for the pre-test was 0.772 which was greater than the alpha value hence the null hypothesis was retained where it would be stated as that there was no statistically significant difference between the independent groups. At the pre-test stage, the groups were at the same level in terms of knowledge of performing titration experiments. Therefore, there was no relationship between the two variables of academic performance and the teaching methods. For the groups to have performed almost the same at pre-test it meant they had almost the same knowledge level at this stage because no method was used to teach them.

4.4.4 Academic Performance at Post Test

The four hundred and eight learners from four different schools were divided into four groups as a requirement in Solomon four experiemental design. The first group was Scratch program group which was taught using scratch program method. The second group was PowerPoint presentation group which was taught acid-base reactions using Powerpoint Presentation method. The third group was Teacher Based Demonstration Experiment(TBDE) which was taught using the Teacher Based Demonstration Experiment method on learning acid-base reaction. The fourth group was a non-intervention group which was not given any intervention.

After the implementation of the intervention in all three groups, a post-test was conducted whose results are tabulated in Table 4.15. Table 4.15 shows the normality test from Kolmogorov-Smirnov and Shapiro-Wilk. The statistical p-value at both tests is less than the alpha value of 0.05 which indicates that there was non-normal distribution of variables between the four groups at the post-test stage. For example, the p-value was 0.016 which was less than 0.05. The null hypothesis was rejected. The conclusion was that there was a non-normal distribution in the data collected as it could not give a bell-shaped curve.

4.4.5 Test of Normality at Post Test

Normality test is used to describe a symmetrical bell shaped curve which has the greatest frequency of scores in the middle with smaller frequencies towards the extreme ends. Table 4.15 shows the test of Normality at post test.

Table 4.15

Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
SCRATCH GROUP	.145	120	.000	.944	120	.000
POWERPOINT	.134	120	.000	.945	120	.000
TBDE	.214	120	.000	.894	120	.000
NON-INTERVENTIONAL	.222	120	.000	.892	120	.000

a. Lilliefors Significance Correction

Furthermore, Table 4.16 shows the group statistics for the post-test stage for all the groups taught using Scratch Program, PowerPoint presentation, Teacher Based Demonstration Experiment (TBDE) and the fourth group which was a Non-Interventional group.

Table 4.16

Post-test Group statistics.

	N	Mean	Std. Deviation	Minimum	Maximum
SCRATCH GROUP	120	81.17	8.544	60	95
POWERPOINT GROUP	120	61.21	9.788	45	80
TBDE	120	20.79	4.798	0	20
NON-INTERVENTION	120	6.00	4.825	0	20

The mean of the group taught using PowerPoint presentation was 61.21 whereas that of the group taught using the Scratch program was 81.17 depicting that it had the highest mean. The third group which was taught using a Teacher Based Demonstration Experiment had a mean of 20.79 and the last group where there was no intervention conducted had the lowest mean of 6.00. This showed that there was no filtration of concepts from the other groups more especially that there was a large difference in the post test results and that the mean of the two groups at post-test was almost equivalent to the mean at pre-test. Even performance, the scratch group performed much better than the group taught using PowerPoint presentation where the highest score for the scratch program group was 95% whereas for PowerPoint presentation was at 80. Using the Scratch program yielded better results as compared to the PowerPoint presentation and Teacher Based Demonstration Experiment.

4.4.6 Friedman Test at Post-Test Stage

Friedman test was also conducted at post-test as there were more than two groups which were supposed to be measured in academic performance test scores. This test would help in either retaining or rejecting the null hypothesis. The null hypothesis being tested here was that there was no statistical difference between the learners who were taught acid-base reactions using Scratch program and PowerPoint Presentation method. Table 4.17 shows the Fried test at Post Test stage.

Table 4.17

Friedman Test at Post-Test stage.

Ranks	
	Mean Rank
SCRATCH PROGRAM GROUP	3.93
POWERPOINT PRESENTATION GROUP	3.08
TEACHER BASED DEMONSTRATION GROUP	1.70
NON-INTERVENTIONAL GROUP	1.30

Test Statistics[a]	
N	120
Chi-Square	331.286
df	3
Asymp. Sig.	.000
a. Friedman Test	

Table 4.17 shows that the Fried Test for all the four groups. Three of the groups were taught using scratch program, PowerPoint presentation and demonstration method while the last group had no intervention respectively.

From Table 4.17, it was revealed that the p-value was 0.000 for the groups which was less than the alpha value ($p<0.05$). This meant that the null hypothesis was rejected. The null hypothesis was that there was no statistical difference in academic performance between the groups taught acid-base reactions using different teaching methods. The null hypothesis was rejected because there was a statistically significant difference in academic performance between the variables (teaching methods) influencing the post-test results of the groups. There was a significant difference in academic performance between the four independent groups which existed at the post-test stage. Among the three teaching methods employed, the scratch program method yielded better results in post-test as compared to the PowerPoint presentation and the Teacher Based Demonstration Experiment method.

When the mean ranks were compared, the scratch program group had a high mean rank of 3.93 as compared to the PowerPoint presentation group which had a mean rank of 3.08 whilst the Teacher Based Demonstration Experiment method had a mean rank of 1.97. Therefore, the group which was taught using the scratch program performed better academically as compared to the other two groups that were taught using PowerPoint Presentation and Teacher Based Demonstration Experiment. Both teacher based demonstration experiments and non-interventional groups had the lowest mean ranks at 1.97 and 1.53 respectively. This last group had no intervention hence the low academic performance which was exhibited. This meant that there was no filtration of information between the groups in the school because the group could have performed better at the post-test had it gained the concepts through the filtration of information from those groups that were being taught. Therefore, the difference in academic performance was really due to the different teaching methods which were given to the different groups. In this regard, the scratch program was seen to be an effective approach in teaching acid-base reactions to grade 11 learners as compared to the PowerPoint Presentation method and the usual business of traditional teaching methods exhibited in most secondary schools.

4.5 Post Hoc Test

Friedman test is an omnibus test more like its parametric alternative where it shows the overall differences but does not pinpoint which groups in particular differ from each other. To determine the actual differences between the groups, a post hoc test is run. To examine where the differences occur, a Wilcoxon signed rank test on the different combinations of related groups. Therefore, in this research, the following combinations were compared:-

- ✓ Scratch program group to PowerPoint presentation group
- ✓ Scratch program group to Teacher Based Demonstration Experiment group
- ✓ PowerPoint Presentation group to Non-Interventional group
- ✓ Teacher Based Demonstration Experiment group to Non-Interventional group

A Bonferroni adjustment obtained from the Wilcoxon test is used because there are multiple comparisons. This would prevent making a type 1 error so that only significant results are declared. The Bonferroni adjustment is calculated by dividing the significance level of 0.05 by the four groups which are being compared as follows:-

$$0.05/4 = 0.01$$

This means that if the p-value is larger than 0.01, there is no statistically significant result.

4.5.1 Comparing Scratch Program to PowerPoint Presentation

The scratch program group and PowerPoint Presentation group were compared in terms of their academic performance as Table 4.18.

Table 4.18

Results from Wilcoxon.

Ranks				
		N	Mean Rank	Sum of Ranks
POWERPOINT PRESENTATION GROUP - SCRATCH PROGRAM GROUP	Negative Ranks	107[a]	58.59	6269.00
	Positive Ranks	5[b]	11.80	59.00
	Ties	8[c]		
	Total	120		
a. POWERPOINT PRESENTATION GROUP < SCRATCH PROGRAM GROUP				
b. POWERPOINT PRESENTATION GROUP > SCRATCH PROGRAM GROUP				
c. POWERPOINT PRESENTATION GROUP = SCRATCH PROGRAM GROUP				

Test statistics

	POWERPOINT PRESENTATION GROUP - SCRATCH PROGRAM GROUP
Z	-9.032[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

The p-value (0.000) was less than the calculated Bonferroni value of 0.01 ($p<0.01$) hence there was a statistical significant difference in academic performance between the two groups. The statistical difference in academic difference between the two groups (Scratch program and PowerPoint presentation) were a result of the difference in the teaching methods used for the two groups.

4.5.2 Comparing Scratch Program to Teacher Based Demonstration Experiment

The scratch program group was compared to the Teacher Based Demonstration Experiment group (TBDE) as shown in Table 4.20. The results of the Wilcoxon test are therefore displayed in Table 4.19.

Table 4.19

Results of Wilcoxon

Ranks				
		N	Mean Rank	Sum of Ranks
TEACHER BASED DEMONSTRATION GROUP - SCRATCH PROGRAM GROUP	Negative Ranks	120[a]	60.50	7260.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	120		

a. TEACHER BASED DEMONSTRATION EXPERIMENT GROUP < SCRATCH PROGRAM GROUP

b. . TEACHER BASED DEMONSTRATION EXPERIMENT GROUP > SCRATCH PROGRAM GROUP

c. . TEACHER BASED DEMONSTRATION EXPERIMENT GROUP = SCRATCH PROGRAM GROUP

Test Statistics

Test Statistics[a]	
	TEACHER BASED DEMONSTRATION EXPERIMENT GROUP - SCRATCH PROGRAM GROUP
Z	-9.534[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

There was statistically significant difference in academic performance between the two groups as the $p<0.01$, $p=0.000$. The two groups had differences because one group was given an intervention using the scratch program whilst the other group had an intervention of being taught using a Teacher Based Demonstration Experiment. Therefore, the difference in academic performance was because of the different teaching methods used between the two groups.

4.5.3. Comparing PowerPoint Presentation to Non-Interventional Group

The PowerPoint presentation Group was compared to Non Interventional group. The Wilcoxon signed rank test Table 4.20 is below:-

Table 4.20

Wilcoxon signed rank test.

Ranks				
		N	Mean Rank	Sum of Ranks
NON-INTERVENTION GROUP - POWERPOINT PRESENTATION GROUP	Negative Ranks	120[a]	60.50	7260.00
	Positive Ranks	0[b]	.00	.00
	Ties	0[c]		
	Total	120		
a. NON-INTERVENTION GROUP < POWERPOINT PRESENTATION GROUP				
b. NON-INTERVENTION GROUP > POWERPOINT PRESENTATION GROUP				
c. NON-INTERVENTION GROUP = POWERPOINT PRESENTATION GROUP				

Test Statistics

Test Statistics[a]	
	NON-INTERVENTION GROUP - POWERPOINT PRESENTATION GROUP
Z	-9.530[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

The p (0.000) value is less than 0.01($p<0.01$) hence there was a statistically significant difference in academic performance between the groups. One group was taught using PowerPoint presentation whilst the last group had no intervention as well as a pre-test. Because of the intervention, there was a statistically significant difference in academic performance between the groups.

4.5.4 Comparing Teacher Based Demonstration Experiment to Non-Interventional

Furthermore, the Teacher Based Demonstration Experiment group was compared to the PowerPoint presentation group. The Wilcoxon Table 4.25 shows the analysis between the two groups:-

Table 4:21

Wilcoxon Signed Rank Test

Ranks				
		N	Mean Rank	Sum of Ranks
NON-INTERVENTION – TEACHER BASED DEMONSTRATION METHOD	Negative Ranks	29[a]	36.69	1064.00
	Positive Ranks	37[b]	31.00	1147.00
	Ties	54[c]		
	Total	120		
a. NON-INTERVENTION – TEACHER BASED DEMONSTRATION METHOD				
b. NON-INTERVENTION – TEACHER BASED DEMONSTRATION METHOD				
c. NON-INTERVENTION – TEACHER BASED DEMONSTRATION METHOD				

Test Statistics

Test Statistics[a]	
	NON-INTERVENTION – TEACHER BASED DEMONSTRATION METHOD
Z	-.275[b]
Asymp. Sig. (2-tailed)	.783
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

The p (0.783) value was greater than the significant value ($p>0.01$) which meant that there was no statistically significant difference between the two groups. Despite one group receiving an intervention, there was no statistically significant difference as both groups performed poorly academically.

4.5.5 Post Hoc Test Analysis

A post hoc test analysis is a statistical analysis that is performed after the data has been collected and the study has come to an end. It is used to identify which groups differ from each other. It is also used to reveal specific differences between three or more group means, and find patterns, relationships or effects that were not initially considered. Table 4.22 shows the overall analysis of the post hoc test.

Table: 4.22

Post Hoc Analysis

Ranks					
		N	Mean Rank	Sum of Ranks
TEACHER BASED DEMONSTRATION EXPERIMENT – NON-INTERVENTIONAL GROUP	Negative Ranks	37[a]	31.00	1147.00
	Positive Ranks	29[b]	36.69	1064.00
	Ties	54[c]		
	Total	120		
POWERPOINT PRESENTATION GROUP - SCRATCH PROGRAM GROUP	Negative Ranks	107[d]	58.59	6269.00
	Positive Ranks	5[e]	11.80	59.00
	Ties	8[f]		
	Total	120		

a. TEACHER BASED DEMONSTRATION METHOD GROUP < NON-INTERVENTION GROUP

b. TEACHER BASED DEMONSTRATION METHOD GROUP > NON INTEVENTION GROUP

c. TEACHER BASED DEMONSTRATION METHOD GROUP = NON INTERVENTION GROUP

d. POWERPOINT PRESENTATION GROUP < SCRATCH PROGRAM GROUP 1

e. POWERPOINT PRESENTATION GROUP > SCRATCH PROGRAM GROUP 1

f. POWERPOINT PRESENTATION GROUP = SCRATCH PROGRAM GROUP 1

Test Statistics

	TEACHER BASED DEMONSTRATION EXPERIMENT – NON INTERVENTION	POWERPOINT PRESENTATION GROUP - SCRATCH PROGRAM GROUP
Z	-.275[b]	-9.032[b]
Asymp. Sig. (2-tailed)	.783	.000

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

There was a statistically significant difference in the teaching methods used in the different groups with $p<0.01$, and $p=0.00$ on the two groups which received an intervention. Whilst $p>0.01$, $p=0.73$ on two groups. A post hoc test with Wilcoxon signed rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at 0.01. There were no significant differences between the Teacher Based Demonstration Experiment and the Non-Interventional Group ($Z=-275$, $p=0.783$). However, there was a statistically significant difference between the Scratch program group and the PowerPoint presentation group ($z=-9.032$, $p=0.000$).

4.6 Interplay Between Attitude and Academic Performance

This section responds to the research question:-

> *How do attitude and academic performance interplay between learners taught acid-base reactions using scratch program and PowerPoint presentations?*

4.6.1 Interplay at Pre-Test

Both the attitude and academic performance of the learners at the pre-test stage were low. For instance, both the Mann Witney U Test and Friedman's test which were used to determine the attitude of the learners at the Pre-test stage revealed that the test hypothesis was retained as illustrated by Table 4.23.

The attitude of the learners at the pre-test was tested using the Mann-Whitney U Test where the null hypothesis was retained. There was no significant statistical difference between the attitudes of the learners in learning acid-base reactions. Both the scratch group and PowerPoint presentation group exhibited the same attitude at the Pre-test.

Table 4.23

Mann Whitney U Test

	Effective interaction among learners	Motivates the learners	Good attitudes exhibited	Active participation
Mann-Whitney U	3333.000	6431.000	6454.000	6598.000
Wilcoxon W	10593.000	13691.000	13714.000	13858.000
Z	-1.530	-1.519	-1.446	-1.222
Asymp. Sig. (2-tailed)	.120	.129	.148	.222

a. Grouping Variable: Different groups

Test statistics

	Effective participation among learners	Motivates the learners	Good attitudes exhibited	Active participation
Mann-Whitney U	3333.000	6431.000	6454.000	6598.000
Wilcoxon W	10593.000	13691.000	13714.000	13858.000
Z	-1.530	-1.519	-1.446	-1.222
Asymp. Sig. (2-tailed)	.120	.129	.148	.222
a. Grouping Variable: Different groups				

For instance, the man witney u test had a significant value of 0.120 which was greater than the p-value of 0.05 (u=3333, p=0.120). The null hypothesis on attitude was retained as there was no significant statistical difference in attitude of the learners at this stage since the p-value was greater than the alpha value of 0.05.

Equally, the Friedman test had a significant value of 0.772 which was greater than the alpha value of 0.05 hence retaining the hypothesis at pre-test. There was no significant statistical difference in academic performance between the learners who were taught acid-base reactions using scratch program and PowerPoint presentation. This meant that at the pre-test level, both the attitude and academic performance of the learners were the same as illustrated by Table 5.29.

Therefore, when the attitude of the learners was low equally the academic performance of the learners was low. As a result, the negative attitude of the learners made the learners perform lowly in the pre-test. It therefore making a good conclusion that there is an interplay between attitude and academic performance. The null hypothesis was retained at the Mann Witney U test on the attitude test and also by Friedman’s test on academic performance as there was no statistically significant difference among the variables.

Table 4.24

Academic performance Interplay at Pre-Test using Friedman Test

Ranks	
	Mean Rank
SCRATCH PROGRAM	1.51
POWERPOINT PRESENTATION	1.49

Test Statistics[a]	
N	120
Chi-Square	.084
df	1
Asymp. Sig.	.772
a. Friedman Test	

4.6.2 Interplay at Post-Test

Both the attitude and academic performance of the learners improved at post-test. However, the learners who were taught acid-base reaction using the scratch program had better attitude features and better academic performance results as compared to the learners who were taught using the Powerpoint Presentation method.

At the Post-Test, the attitude of the learners was again tested using the Mann-Whitney U Test. The Mann-Whitney U test uses both the mean ranks and statistics. The mean ranks at the post-test were higher for the scratch program group as compared to the PowerPoint presentation group. This was as a result of the intervention the two groups underwent. The scratch group was taught acid-base reaction using the scratch program whilst the PowerPoint group was taught using the PowerPoint presentation. As a result, most of the learners under the scratch program didn't agree with the statement as compared to the learners under the PowerPoint group. The higher mean ranks suggest that the learners' attitude had improved under the scratch program as compared to the PowerPoint presentations. As a result, it can be concluded that both teaching methods bring about an increased motivation which in turn raises the attitude of learners towards learning acid-base reactions. However, the scratch program when used in teaching increases the learners' attitude higher than the PowerPoint Presentation method and Teacher Based Demonstration Experiment.

Table 4.25

Mann Whitney U test

Ranks				
	Different groups	N	Mean Rank	Sum of Ranks
Effective interaction among learners	SCRATCH	120	152.72	18327.00
	POWERPOINT	120	88.28	10593.00
	Total	240		
Motivates the learners	SCRATCH	120	126.91	15229.00
	POWERPOINT	120	114.09	13691.00
	Total	240		
Good attitudes exhibited	SCRATCH	120	126.72	15206.00
	POWERPOINT	120	114.28	13714.00
	Total	240		
Active participation	SCRATCH	120	125.52	15062.00
	POWERPOINT	120	115.48	13858.00
	Total	240		

Test Statistics

	Effective interaction among learners	Motivates learners	Good attitudes exhibited	Active participation
Mann-Whitney U	5658.000	4800.000	5063.000	4533.500
Wilcoxon W	12918.000	12060.000	12323.000	11793.500
Z	-3.490	-5.160	-4.580	-5.865
Asymp. Sig. (2-tailed)	.000	.000	.000	.000

This also was observed in the academic performance where Friedman's test had a significance of 0.000 which was equally less than 0.05, making the test hypothesis rejected. This, therefore, shows that an increase in attitude makes the learners have an improved academic performance as depicted in Table 4.26. There is a correlation between positive attitude and high academic performance.

Table 4.26

Academic Interplay at the post-test stage using Friedman's test.

Ranks	
	Mean Rank
SCRATCH PROGRAM GROUP	3.93
POWERPOINT PRESENTATION GROUP	3.08
TEACHER BASED DEMONSTRATION EXPERIMENT	1.70
NON-INTERVENTIONAL GROUP	1.30

Test Statistics[a]	
N	120
Chi-Square	331.286
df	3
Asymp. Sig.	.000
a. Friedman Test	

The learners who were taught acid-base reactions using the Scratch program performed better academically as compared to the other two groups. The scratch program project proved to provide learners with a high cognitive retention rate as compared to the PowerPoint presentation and Teacher Based Demonstration Experiment approach as different learners' learning modalities are incorporated in the program to have an effective learning process with a variety of multi-modal and multi-sensory which adopts to their different learning strategies.

However, both in pre-intervention and post-intervention stages, there has been an interplay of attitude and academic performance. At the pre-test stage, the attitude of the learners was low hence the academic performance was equally low. At the post-test stage, the attitude of the learners had improved hence the academic performance of the learners equally improved. Whenever the attitude of the learners improved, the academic performance of the learners equally improved therefore there is an interplay between attitude and academic performance of the learners.

Mwamba (2021) supports that an improved attitude of the learners results in improved academic performance. When the learners are motivated, they would be able to learn better and retain more knowledge and skills. Motivation enables learners to be interested in learning acid-base reactions which improves their attitude. This, therefore, brings a conclusion that an increase in attitude results in an increase in the academic performance of the learners.

This interplay between attitude and academic performance is supported by the conceptual framework. Both academic performance and attitude were the dependant variables which were being influenced by the teaching methods which were the independent variables. As the academic performance of the learners improve, it motivates the learners to work extra hard to even improve better. Therefore, when the learners' attitude improves then there academic performance also improves. The learners' motivation is enhanced when the academic performance improves. As a result, the learners' attitude should be improved in order for the learners' academic performance to be improved. The scratch program being a learner centred approach and activity based improved the learners' attitude better than PowerPoint Presentation method. As the learners' attitude improves, their academic performance also improves. In this scenario, the academic performance of the learners under scratch program improved better than the one for Powerpoint presentation.

4.7 Summary of Results

Both qualitative and quantitative analysis revealed that Scratch program was a better method of teaching as it improved both the attitude and academic performance of the learners. Scratch program method has shown that it's more beneficial when being used in teaching titration especially when coding of the apparatus is done compared to PowerPoint presentation and Teacher Based Demonstration Experiment method. Both the attitude of the learners and the academic performance improved after the method of scratch program was used because of the inclusion of the learning modalities which were incorporated when the scratch program was created. Besides, scratch program develops critical thinking skills, problem solving skills, communication and collaborative skills among learners. This enable learners to effectively interact during and after the lesson. The learners became more interested in the lessons because scratch program motivates to continue with learning as its play based approach. The learners achieved better results when the method of scratch was used as compared to the PowerPoint presentation as there is active participation among the learners.

4.8 Chapter Summary

The chapter dealt with both quantitative data and qualitative data where the quantitative data was analysed using SPSS. The attitude was narratively analysed and presented. The results showed that the group taught using scratch program performed better as compared to the group taught using PowerPoint presentation. The group taught using the scratch program had attained better attitudes towards learning of titration as compared to the group which was taught using PowerPoint presentation. The next chapter is on Discussion of findings.

CHAPTER 5

DISCUSSION OF FINDINGS

5.1 Overview

This chapter looks at the discussion of research results, implications and limitations of the study, recommendations, and conclusions of the study which was hinged on two research questions.

5.2 Summary of Study Results

This research was assessing the impact of Scratch program method, PowerPoint Presentation method and Teacher Based Demonstration Experiment on acid-base reactions to learners in selected Upgraded Secondary Schools in Mongu district. The study employed Solomon Four Experimental Design where academic performance and attitude towards titration using Scratch program, PowerPoint Presentation and Teacher Based Demonstration Experiement methods were assessed using pre-post performance test, a Likert scale questionnaire, interviews, and observations on the four hundred and eighty Grade Eleven learners were randomly sampled.

This study on application of virtual laboratory would be applicable in upgraded secondary school as the learners would still use the digital platform to continue even when they are home. As a result, learners would still more be active participants in the learning process. The learners are not attending study periods due to lack of adequate classroom space therefore the scratch program would assist in having study materials at their finger tips. Equally, scratch program would be more useful in a normal school as it would supplement wet laboratory activities. This would enable learners to have a continuity of academic activities even at their homes by using the digital platforms.

The results presented in chapter four indicated that Scratch Program was a better method in achieving and enhancing good attitudes and best academic performance as compared to the PowerPoint Presentation method. Both Scratch program and PowerPoint Presentation methods of teaching yielded better attitudes and better academic performance but the Scratch program was rated higher as compared to the PowerPoint Presentation method because of its high interactiveness in nature.

5.3 Discussion of Learner's Attitude Towards Acid-Bases Reactions

This section looks at learners' attitude towards acid-base reactions. An attitude can be defined as a person's feelings, thoughts, and predispositions to act towards an aspect in his/her environment (Robertson, 1998). The requirement of a specific object is an important attribute of attitude, distinguishing it from personality, which reflects a person's predispositions across a range of situations (Arnold et al., 1998). In this study, therefore, the study was looking at the attitude towards learning learning acid-base reactions.

The first research question read as follows:-

1. *What are the differences in attitude of the learners taught acid-base reactions using scratch program and those taught using PowerPoint Presentation method*?

The first research questions were assessing the difference in attitudes of learners taught acid base reactions using scratch program and those taught using PowerPoint presentation.

The performance test results were as a response to the second research question which read as follows:-

2. *What are the differences in academic performance between learners taught acid-base reactions using scratch program and those taught using PowerPoint Presentation method.*

The research questions above were seeking responses on the differences in academic performance between learners taught using Scratch Program and also the ones taught using the PowerPoint presentation. According to the achievement test results produced, the group which used the Scratch program performed much better as compared to the group that was taught using the PowerPoint presentation. The learners in the scratch group were able to perform titration experiments better than those in the PowerPoint presentation group.

5.3.1 Scratch Program on Learners' Attitude and Academic Performance

Scratch program teaching methods brought about a significant change in attitude of the learners towards learning acid-base reactions. The learners had an improved attitude from pre-test to post-test. Scratch program which is a free programming language interactive stories, games and animations created by the learners proved that it had improved the learners' attitude towards learning acid-base reactions as compared to the PowerPoint presentation and Teacher Based Demonstration Experiment. The first question was answered to determine if the learners had a positive change in attitude when compared at pre-test and at post test. For instance, the candidates at the upgraded secondary schools such as Kanyonyo Secondary School have been performing poorly because the teaching methods used were teacher centred. Teacher centred methods don't promote effective interaction among the learners which inhibits motivation to learn further than what the teacher provides. The less participation of the learners in the process of learning makes concepts to be in short memory retention.

However, the scratch program method in this study engaged learners such that there was effective interaction during learning acid-base reactions. Scratch program brought abstract scientific ideas to life by providing visual representation, allowing learners to better grasp complex processes of calculating the concentration of the titrand and titrant. As learners enjoy working with peers, they involved themselves actively in the learning process because their attitude became positive as illustrated by the conceptual framework. The learners' active involvement and participation in the learning process enables them to apply scientific concepts and test their ideas and theories. There is a correlation between attitudes towards the subject and student achievement (Sumedha & Sunevirathne, 2024)

Additionally, the scratch program exhibited that better attitudes and academic performance by the learners were revealed as compared to the other two teaching approaches. Brennan (2012) supports that scratch program helps learners to develop critical thinking, problem solving and computational thinking skills. The conceptual frame also gives evidence that scratch program provides the twenty first century skills. As the learners create projects using scratch program, the critical thinking and problem solving skilss are developed. This makes learners to perform better when scratch program is used in the teaching and lerning process. Computational thinking skills are developed when learners acquire skills in coding logic by dragging and dropping code blocks. In scratch program, learners develop programmatic thinking where problems are broken into smaller subcomponents through the assembly of code blocks and by exploring multiple solutions to the problem. Bopitiye (2024) supports that attitude towards acid-base reactions significantly influence learners' achievement.

The learners who were taught acid base reactions using scratch program had better attitudes compared to the learners who were taught using PowerPoint presentation because scratch program incoporates all the four learning modalities of the various individual learners. Scratch program has auditory characteristics where those learners who grasp concepts using their hearing aspects are included. Even those who learn effectively when they see are met at their point of need. Both those learners who learn through feelings and movement are included when learning acid-base raections are done using scratch program. Learning style (2008) reviewed that how concepts are presented determine the retention level of the ideas delivered. Thus, scratch program assists in having the learners to grasp the concepts as it promotes high retention of the materials presented. This is supported by the connectivism theory where a learner would plug and play to learn the needed concepts from the created scratch program.

Besides, scratch program when used in the learning process encourages a shift from short term memory to long term memory through repetition of the same activities on a particular concept. Long term retention is improved through the spacing between as repetitions increases (Coffield et al., 2004). Spacing can improve retention especially when combined with retrieval leads to better and effective learning. When scratch program is used in class, the learners would continue doing the same activity even at their homes. As a result, through repetition, the concepts are assimilated in the long term memory. This brings the retention to be higher when scratch program is being used. Each time that information is repeated or reinforced, different sets of neurons fire simultaneously, strengthening the synaptic pathway that connects them with one another therefore creating a long term memory (Dumbo, Myron, & Howard 2007).

Scratch program yielded better results both academic performance and attitude of the learners because it used to rely information in piece meals as a learner must actively process and analyse the new knowledge for it to be intergrated into the cognitive structure. Meaningful learning depends on active cognitive processing in learner’s working memory. However, If learners encounter too many elements in the presentation of multimedia information (animation, graphics, sound, text), working memory can be overwhelmed resulting in poor retention (Coffield et al., 2004). Therefore, excessive cognitive load impedes effective learning. As a multimedia, scratch program can be created in such a way that it provides concepts in pieces to avoid a cognitive overload which would impede effective acquisition of concepts. The learners were able to revisit the concepts as need arise at different times, in rearranged contexts, and from different conceptual perspectives of the acid –base reactions. This resulted in the learners performing better at post test academically.

Above all, scratch program facilitates the activation and retention of prior knowledge by focusing on knowledge construction using the experience as a feature of pragmatism. Pragmatism supports both theory and practice hence the learners would be able to acquire skills and knowledge through scratch program. Using the coding language from scratch, the learners are able to formulate new concepts such that long term memory is supported. As learners construct the new knowledge, there is high retention rate among them of the concepts previously learnt (Dumbo, Myron, & Howard 2007).

Furthermore, scratch program which was created for this involved animations which are based computer programs that bring about an abstract process of any system. Most of the upgraded secondary schools lacked or have indequate laboratory apparatus hence the concepts were learnt in an abstract manner. Therefore, the created scratch program on titration enabled learners to manipulate variables then keenly observe the outcomes as if it were in real environments with real objects. The learners acquire skills and knowledge when learning is concrete. For instance, learners fail to comprehend when its abstract learning on titration unless a practical is give hence the created titration project on scratch program being a concrete example helped learners to comprehend the acid-base reaction concepts. This means that when Scratch program are used to depict the real environment the learners comprehend better hence improving their academic performance. As a result, the Scratch program is recommended for bringing real learning situations to a classroom situation particularly when the concepts which are suppose to be learnt can be displayed in a classroom situation. This enables the learners to aquire necessary skills and knowledge toppled with more practical work.

The researcher created animation of titration that had embedded naration of examples on how titration could be performed particularly looking at the concentration of the titrant calculations. Furthermore, when the titration activities were done, learners could easily calculate the different concentrations of acids and alkalis in the activities. As the learners switching from one practical example to another, they increased their ability to handle the questions which were in line with titration. Learners engage one another on how they would switch from one example to another hence they have participated such they would help each other in the process. As the learners were working in groups it meant that they would require each other to participate in order for the concentration to be calculated.

Scratch program brought out better attitudinal and academic scores because of its interactiveness between the activities and the learners. The formulated scratch program activity on titration was more engaging and the learners learnt practically how to titrate. As the scratch program was interactive, they learners collaborated with one another on successfully completing the tasks. For examples, learners were able to slow down or stop the titration process and start all over again. Therefore, these purposiveful stops enabled the learners to appreciate the colour changes which takes place at the end point of titration. As a result, both attitudes and academic performance of the learners improved as the scratch program was used.

Furthermore, the scratch program which the researcher created on titration promoted the values, skills and knowledge as propounded by the Zambian school curriculum framework. One of the skills which the scratch program brought out at excursion is demonstration. Learners who were using the scratch program were able to demonstrate to one another on how titration was to be done. As a result, the learners also gained the knowledge on using titration method to prepare soluble salts and perform easily the calculations on determining the concentration of both the titrate and titrant. The scratch program was a safe way of performing these activities on acid-base reactions hence the learners gained values of awareness of the dangers of acids and bases including applying safety rules in preparation of salts.

Addition, the Zambian school curriculum framework supports learners to be wholly involved in practical activities. As the learners were calculating the concentration of the titrant, there was a great need to correctly read the volume level in the burette then equating to the concentration and volume of the titrant in the conical flask. Scratch program develops computational skills among the learners. As the learners interact, they learn how to calculate the concentration of the titrand using the scratch program through plug and play as promoted by Connectivism theory.

Besides, these learners were also collaborating and communicating with each other hence skills such as communicating and appreciating one another was enhanced as provided for in the Zambian School Curriculum. Therefore, the Zambian School Curriculum (2013) support meaningful learning which was encompassed by the scratch program which was created on the titration. This brought about high retention rate on the part of the learners as they were wholly involved in the learning process.

As a result, both academic performance and attitudes towards learning acid-base reactions were enhanced by Scratch program method. This is because Scratch program is a learner centred method that is justified by connectivism learning theory. As learners are actively involved in the learning process by using computers, they gain knowledge and skills such as trying new possible ways of finding the concentration of the titrant. Both motivation and attitude are positively enhanced when scratch program is used in the learning process.

The learners who were taught using the Scratch program became more interested in the process of calculating the concentration of the acid because the learners became attached to the animations. Besides the learners also became motivated as each concentration correctly calculated made them reach another one hence the zeal to continue working on the questions which involved the finding of the concentration.

The study aroused the learners' attitudes by introducing the computer gadgets in the learning process. This is supported by Mwamba (2021) who revealed that PhET simulations had positive impact on both academic performance and attitude. Whenever, the attitude of the learners are aroused, their academic performance improves. As a result, there is a great need to improve the attitude of the learners in order to have the learners' performance improved.

When Scratch program is used collaboratively, they encourage teamwork, peer learning and computational attitudes (Arda, 2005). As a result, educators can assign group tasks that require learners to collaborate on coding projects, fostering communication skills and enhancing problem-solving abilities as they work together to achieve common goals.

The study takes note that learning is suppose to be extended outside the classroom. Therefore, what the pupils learn in class is carried to their homes especially that the digital gadgets are being used. To support the study, Denilla (2010) points out that the attitude of the learners towards learning determine the engagement of the learner with the material they are learning even after classroom session. This therefore entels that when a child has a positive attitude and like what they have learnt, the child would experience some success and would work more effectively.

In support, Matovu, Matiye and Ungu (2023) looked at how the Immerse Virtual Reality based learning would improve science teaching and learning in terms of academic performance and attitude. In line of attitudes, it is state that learners exhibit a poor attitude towards a particular concept because they consider it difficult which retards their academic performance. As a result, the inclusion of learner centred approaches would improve the attitude of the learners. This is true more especially when traditional methods are used which make the learners to be stagnated.

However, when the concepts are illustrated using animations and videos, the easier it is to understand on the part of the learners as it uses the learners' interest to learn in this digital world. As the concepts become less challenging, the learners' attitude is aroused as their extrinsic motivation is raised to continue learning. Generally, most researchers state that whenever learners perceive a concept to be hard, their performance reduces because of their poor attitude towards that particular concept. Therefore, there was a great need in this study to arouse the interest of the learners which could, in turn, improve their attitude which would enhance improvement in their academic performance.

This study is as well in line with a study by Vandenpals (2008) at Umea University where the researcher looked at animations in university chemistry education cognitive and affective aspects. The study was based on acid/bases reactions where there was an investigation on whether the students' attitude could improve using simulation exercise. This was a mixed study where both qualitatitave and quantitative sudy approaches were used. The findings of the study concluded that the students' attitude had improved greatly when using simulation exercise to study acid/bases reactions. In line with the current study, its relevant in that both are dealing with acid base reactions. However, only that the study by Vandenpals (2008) dealt with qualitative analysis of solutions as compared to titration for the current study. Its in this line that even when scratch program where animations were made and used, the learners' attitude improved as they became more interested in the lessons involving acid-base reactions. Learners could be observed in their groups whenever they were performing titration using different acids and bases. Whenever, the learners are taught using games their attitude changes positively because they feel as if they are playing whilst doing an academic exercise hence the comprehension is high. A positive change in attitude brings about an increased academic achievement as the learners' interest is captured.

Above all, the groups had a little percent of absenteesm as mostly the groups were available in their numbers. This is supported by Armoni (2015) who found out that scratch programme increased the environment in computer studies classes. Therefore, during the conduction of the current studies, the learners were ever rushing to come to class to learn using the computer gadgets. The learners were observed to display higher levels of motivation and self efficacy. Sometimes learners absent themselves from classses because the learners feel the lessons are monotonous and boring hence stay home where there are a lot of activities to do. In some cases, the learners when what they cherish home is brought in a classroom, the learners would learn better such that learning is never an ending continous process. The learning process even continous when the learners are at home. Therefore, this would motivate the learners to continue learning even when at home as they would create their own games when at home. This would promote learners to be responsible for their learning process. This is because of fewer learning difficulties and they achieved higher cognitive levels of understanding of most concepts.

Above all, scratch program enable learners to learn both from class and outside class as supported by connectivism theory. Connectivism theory recognises that learning is not liited to classroom walls (Bell, 2010). Scatch program yielde better attitudes and better academic performance because of its connectedness. As learners leave the classroom environment, the would connect to the learning process through contact with the digital world. This therefore encourages students to connect with and learn from the wider community. This arouses the learners interest and they tend to learn very well because of high retention since scratch program supports interactive activities.

5.3.2 PowerPoint Presentation on Learners' Attitude and Academic Performance

The PowerPoint presentation also enhanced an improvement on attitude and academic performance of the learners. The PowerPoint presentation promotes interest in the learning of titration particularly when videos are presented because of technological tools which excite them to continue working. This enhances the learners' motivation to continue working on the improved academic work.

Microsoft PowerPoint presentation is an easily to use tool for most teachers with a wide range options to use when teaching various concepts especially in the field of science and particularly chemistry where different techniques are required to teach varying topics. For instance, when the learners are covering a topic on balancing of chemical equations but another concept on may be writing chemical equations comes in, a teacher can modify the slides in such a way that the concept is taught. As slides are being made,

Besides, PowerPoint enables learners to utilise similar technological equipment and multimedia tools to work like scientists by collaborating with peers. For instance, the collaboration enhances peer work among the learners which results in improved attitude towards learning acid-base reactions. The learners become more interested in the process of performing titration experiements as they become attached to the technological tools.

The PowerPoint presentation method motivated the learners as they watched video lessons on YouTube. However, the major hindrance was poor network which made comprehension not to be fully understood hence couldn't bring out desired positive attitude among the learners.

As observed above, the learners' attitudes towards learning acid-base reactions had been improving satisfactorily from pre-test activities to post-test activities for both Scratch program and PowerPoint presentation groups because of the change in learners' beliefs about knowledge and learning influence motivation (Windschitl, 1998), strategy selection and socio-cognitive engagement when working with peers (Hogan, Nastasi, & Pressley, 1999), and ultimately, the learning outcome.

However, the use of PowerPoint presentation method as teaching approach has not improved the learners' academic performance and attitude due to its limitations. Powerpoint presentation is less interactive compared to virtual laboratory where the learners interact with one another as they create a scratch program. The only interactive features which PowerPoint presentation methods provide are hyperlinks, video files and audio recordings. Scratch program assists learners in developing critical thinking, problem solving and computational thinking skills which are not available to PowerPoint presentation methods. These features developed by scratch program promotes experimental skills needed in learning acid base reactions. Mason and Hlynka, (1998) states that the evidence that PowerPoint presentations influence learning is sometimes not seen to be entirely true because of the lack of interactiveness by the learners. Bryant and Hunton (2000) supports that the degree of improved learning is a function of a complex set of interactions among learner and medium attributes.

5.3.3 Teacher Based Demonstration Experiment on Learners' Attitude And Academic Performance

The learners' academic performance and attitude insignificantly improved when a teacher based demonstration experiment was used in the teaching process. This was a result of being less interactive compared to the other teaching approaches used. The academic performance of the upgraded secondary school in Table 1.1 has been poor because the teaching approaches used were not providing learners with better attitudes. The demonstration method was not interactive among the learners and with the learning concepts. Learners rarely had hands on so the comprehension level was very low. When the demonstration method is performed, the learners need to be wholly involved in groups for the concepts to be understood. However, if the teacher just demonstrates and learners observe, they tend to retain little knowledge.

Teacher Based Demonstration Experiment method tend to make learners fail to apply higher order thinking processes which are required in some examination questions. Bwalya et al. (2024) supports that learners taught using Teacher Based Demonstration Experiment method were not able to answer questions that were at the analysis level on Bloom's taxonomy. This causes learners who don't integrate interactive methods to perform poorly in the examinations as their attitude is negative.

The integration of ICT in the teaching and learning process of science improves both the attitude and academic performance of the learners. Arda et al. (2005) state that learners who were taught acid-base reactions using computer-aided methods developed better attitudes and performed better in achievement tests compared to learners who were taught using traditional methods. This is a result of lacking critical thinking and problem-solving skills as the teacher is at the centre stage of the learning process.

When the Teacher Based Demonstration Experiment is used, the learners don't develop communication and collaborative skills. As a result, the learners are not active in the learning process but passive. The passiveness of the learners makes them to fail to comprehend the concepts needed. This is the reason the scratch program assists in cultivating these skills so that the learners comprehend what they are learning as actively as possible.

5.4 Comparison of Scratch Program and PowerPoint Presentation Methods

5.4.1 Attitudes of Learners

Both groups showed a trend where they were progressing satisfactorily as the lessons continued. As the lessons commenced in the first week, most groups scored a mark each as participation and attitude were not satisfactory. In the third session, most of the learners started participating in the lessons as one group from the Scratch program scored a 5 which was a high score whereas most groups had improved from one score to two and three scores. This last session saw most groups scoring five which was the highest score. This meant that the learners had improved their attitude towards performing titration. The learners had improved because their interest was aroused to work together to learn how to calculate correctly the concentration of the titrants. Where one failed, another learner helped to get to the desirable and correct answer. The learning process involves social forces that activate behaviour. Whenever the social interaction is improved, the learners become attached to the learning process hence the acquisition of the knowledge and skills. This enables the learners to gain the much needed scientific concepts to learn the processes of scientific field.

On the lesson observation, the learners were seen co-operating with one another to solve calculations on titration. The learners also were observed helping one another to handle the computer and play the animations to conduct the titration experiments. The learners who were ahead in terms of knowledge acquisition and knew how to perform the experiements were helping those who were lagging behind. Therefore, the learners working in small groups was a good approach as the learners were able to teach one another. The lesson observation, therefore, reviewed that the learners had good teamwork. However, it was observed that the learners who had lessons using Scratch program had better teamwork and co-operation because of the animations which were coded which demanded them to co-operate with one another as compared to those in PowerPoint presentation. This, therefore, indicates that the learners had actively participated and were involved wholly in the lessons.

Besides, the learners also enjoyed the calculations which were involved in the acid-base reactions that were being offered. The learners enjoyed the lessons because they were entertained and motivated by the animations and also it was nice to watch youtube videos which were showing how to perform titration. As these teaching approaches were interesting to the learners, the learners were encouraged to continue using animations and watch videos hence enabling them to conduct titration in a good manner. As the learners seemed to be working tirelessly in groups, it was observed and confirmed by the interviewees that they enjoyed what they were doing. This was further confirmed by the learners' better performance at post-test as their enjoyment enabled them to work hard to perform titration and calculate the concentration of the titrants.

The use of Scratch program and PowerPoint presentation tend to be effective at assisting learners to develop satisfactory attitudes towards learning acid-base reactions. Herraez (2022) states that if Scratch program animations(simulations) are correctly used in classes where the learners are having challenges in gaining a meaningful understanding of scientific concepts, such as performing titration, the learners are highly likely to show significant interest in the topic which In turn improves their academic performance significantly. The learners continue working on various projects because of their interest in learning because of the motivation gained. The scratch program provides a more active and significant learning by engaging students in the process of learning, to support and facilitate the practical sessions. Therefore the use of scratch programs can be seen as an effective solution that can improve the learners' academic performance as learners are wholly involved in the process of learning. In support too is Darhmasur et al., (2015), who supports that using scratch environment for learning programming such as scratch highly motivate students and empower to purse their studies in programme. Learners who are highly motivated have a drive to acquire some skills and knowledge hence improve their academic performance. Therefore, this extrinsic motivation coming from a teaching methodology is very good to improve the academic performance of the learners. It shows that the learners who are highly motivated acquire skills and knowledge better than those who are less motivated.

Both the groups which were taught using Scratch program and PowerPoint presentation expressed that the teaching methods were interesting and enjoyable. The learners expressed interest in learning titration using the two teaching approaches. The learners stated that the teaching approaches were interactive such that the other members could teach those who were not performing well. As a result, they participated highly in the lessons as compared to other topics which were taught using other methods. Besides, the active participation and involvement enabled the learners to gain skills and knowledge on titration. The learners interviewed were optimistic that they learnt correctly how to perform titration.

Both the methods of teaching were improving the academic performance of the learners. However, at the post-test level, the mean scores of the two different groups were compared where the results indicated that there was a statistically significant difference between the mean score of the PowerPoint presentation approach group and the Scratch program approach group. The implication was that when teaching titration using Scratch program yielded significantly better results as compared to using the PowerPoint presentation approach. The Scratch program approach motivated the learners very much such that playing the games was very good hence making several attempts in calculating correctly the concentration of the titrants. The learners were actively involved in the lessons and also co-operated with one another. This assertion is supported by a recent study by Adewole (2014) that stated improved attitudes had a positive contributing factor for higher achievement. Because of the more improved attitude in learners who were taught using Scratch, they performed better in post-test achievement test where their mean score was higher as compared to the mean score of the group which was using PowerPoint presentations.

Another aspect of the virtual laboratories was its ability to be determine the level of engagement by the learners when learning. Those students who were fast with scratch program would assist others to learn well. Therefore, the learners would steadily progress from being begginners to the masters of knowledge. Therefore, the scratch program is an engagement level game where you start from simple to complex. Agostinho (2009) supports that virtual laboratories enable the learners to be engaged in the learning process such that the learners would be even more engaged in the learning process when at home. As a result, the learners would be able to continue learning even at their own pace at their homes. This would facilitate the acquisition of skills and knowledge. Therefore, the educators would need to use the teaching methods which would be more engaged to make learners to learn well.

In the same regard, virtual laboratories would curtel absenteesm among the learners. When learners are engaged in activities which make them attend classes, they become wholly committed to attend classes. It has been noted that one of the reasons as to why learners perform poorly academically is absenteesm. Therefore, when virtual laboratories are used in the teaching and learning in classes, the learners would be attending classes. The click and learn is an activity which the learners are engaged when learning using digital platforms. Therefore, this makes the learners to collect the desired and needed academic information from the digital gadgets whether in a school set up or at their homes. In this vain, the learners become responsible for their learning. This is supported by Matovu ,Matiye, and Ungu, (2023) who did a study on Immersive virtual reality where participants reported engagement and motivation as the leaading cause of good academic performance among the learners.

Therefore, when learners are engaged, the lessons are learner centred hence the learners become more emenced in the learning process. When the learners are engaged, they are acquire skills and knowledge in the learning process. As a result, the learners become more responsible for their learning process such that they acquire the needed skills and knowledge. This is in line with the Competence Based Curriculum (CBC) on the synthesis stage particularly on extension where learners are to conduct research. Scratch program would enable learners to perform research whilst there are at their homes by conducting practical activities.

On the contrary, Flan, Garcia, and Serrano, (2023) pointed out that there were statistically significant differences in favour of traditional laboratories in all studied variables. This was because students had showed more positive attitudes towards traditional experiments. This was so because to learn using virtual laboratories, both the teachers and learners need to be computer literate with basic computer skills and knowledge. Those learners who who may be involved in the virtual laboratories and are not having basic coding skills may find it hard to learn scientific processes using virtual laboratories. In support is Armoni (2015) who indicated that sometimes learners would rush to the computer laboratory to learn than they would do in a traditional classroom setting. This shows that when the learners are well knowledgeable in computer and what they can learn from the computer, they would be the first ones to get into the computer laboratory to learn.

As the learners get to be familiar with the importance of virtual laboratories such as self reliance and autonomy with individual responsibility in the learning process, they would really be ready to use the digital world to learn. This would in turn improve the academic performance of the learners using the virtual laboratories. In support of this is Spernjak and Surgo (2018) who states that most learners prefer a computer supported laboratory mostly followed by a classic laboratory with a computer simulation. This improves both the academic performance and attitude of the learners. Even Tuysuz (2010) supports that virtual laboratories applications made positive effects on learners' academic performance and attitudes when compared to traditional methods of conventional laboratories.

Additionally, conventional laboratories and virtual laboratories complement each other in terms of knowledge acquisition. Andrew, Leung, and Nicolas,(2022) reviewed that scratch program projects brings about independent learning which had an overal positive impact on learning when used in conjunction with traditional methods. This means that the schools that have better conventional laboratories would use virtual laboratories to make the learners continue to learn even outside the classroom. This would make the learning process to be continuous such that they learn even in their homes. This would enable the learners to be responsible for their learning. As they become independent learners, they become responsible for their learning process hence acquiring the necessary scientific skills and knowledge. Herraez (2022) supports that learners were able to assess themselves automatically as the virtual laboratory was ongoing hence they were motivated to continue practicing as they had immediate feedback. This increased their interest in learning because of motivation as compared to conventional laboratories.

Independent learning allows learners to have discussions at higher levels than in a led classroom situation. As the learners make animations and code apparatus to make experiemental procedures, they become more interested in the questions that arise from the process. This is supported by Alexandar et al., (2017) who concluded that virtual laboratories have the potential to improve student’s pre-laboratory preparation. This was coming from the fact that learners would perform independent work before the experiementation. As they prepare, they would be using the virtual laboratories to do some independent individual work aimed at the implementation of laboratory work. This would make the learners to be able to consult one another as they use the computer gadgets to perform the activities. This shows that virtual laboratories can be used in many forms to retain the scientific skills and knowledge.

The independence of the learners is supported by Lage (2000) who discusses the concept of inverted classrooms where traditional lecture content is delivered outside of class allowing more time for interactive activities. As learners acquire scientific skills and knowledge from the learning process using the virtual laboratories, they would continue processing the academic activities at their various homes as long as they have the digital platforms. Therefore, virtual laboratories would be more useful to the learners as they would be engaged in the lessons even in the absence of the teacher. It has been noted that digital platforms are abused by most people but when these tools could be used for the betterment of the learners it would be a positive mind change for the learners. As a result, the digital platform users would be more responsible when these platforms are used for the good works instead of the abuse which is seen online nowadays.

Virtual laboratories particularly scratch program enhance learners’ interest and motivation for learning. This is because when the chemical animations are used to visualise the chemical phenomenon easily. Liminous, Roberts, & Papadopaulos, (2008) proves that virtual reality environment could raise students’ interest and motivation for learning. Virtual laboratories were ethusiatic as most learners had feeling that they were seeing inside the chemical reactions and they were viewing the 3 dimensional(3D) molecules as if they were real objects. As the motivation and interest of the learners are aroused, the academic performance of the learners is enhanced such that it becomes more of a circle. The use of the connectivism theory assisted the learners to be in contact with their learning materials hence their attitude improved.

Virtual laboratories bring high order learning skills and knowledge. The various taxonomies depict knowledge as coming from a lower level to a higher level. In this regard, learning is a building process from what is known to what is unknown. It's a spiral where concepts are built on one another hence the virtual laboratories would improve the academic performance of the learners. When the virtual laboratories are used in the teaching and learning, the learners gain analytical and critical thinkers. Alexandar et al., (2017) support that learners participate in discussions at higher levels than in previous years when virtual laboratories were not used. The higher learning levels were attainable because the learners had improved attitudes and motivational levels because of the use of virtual laboratories. Accordingly,virtual laboratories could be used potentially to improve learners' pre-laboratory preparations.

Virtual laboratories are cost effective for institutions of learning as compared to the conventional laboratories. Kallies and Sypasas, (2018) states that to run hands on laboratories one needs space, equipment and staff so the virtual laboratories could help to reduce the total cost and still complement physical presence. To perform virtual laboratories, an already existing computer laboratory in a school could be used in teaching science concepts, skills and knowledge. The virtual laboratories would be as considered to be as real as the physical laboratory activities. As a result, instead of procuring glass ware for the laboratories, an institution would procure more digital platforms for the accessibility of the internet needed in some cases to download the much needed software applications.

Virtual laboratories enhance practical work to be done. In support equally are Ayas and Tatli (2013) who looked at the alternative to the neglect of performing laboratory applications for a variety of reasons. The study reviewed that laboratory applications have generally been neglected in recent educational environments for a variety of reasons. One of the reasons cited was the high cost of the laboratory equipment. Therefore, a virtual laboratory would be an alternative to this scenario prevailing in most learning institutions as developed virtual laboratory platforms were as effective as the real laboratories.

Apart from that, virtual laboratories would enable the teachers and learners to conduct laboratory activities that are spontaneous and dangerous in a more safe way. The extremely spontaneous laboratory activities could be slowed in motion using the virtual laboratories. Thereby making the learners observe clearly the reactions as they happen. This would assist the learners to make concise conclusions on particular chemical phenomenon. In chemistry, there are experiments that are conducted which are very dangerous in conventional laboratories.

Some chemical reactions are explosive such that if they are not conducted in a fume cupboard, there would be injuries to the experiementers. Therefore, the introduction of virtual laboratories would be good for the institutions to conduct these dangerous laboratory activities in a more safe way. At other times, there are illustrations which could be explained using the virtual laboratories. The virtual laboratories are important as a tool of learning as its effective in teaching learners scientific skills and knowledge.

5.4.2 Academic Performance of the Learners

The learners were taught acid-base reactions using both scratch program, PowerPoint Presentation and Teacher Based Demonstration Experiment methods. From the findings, it was discovered that learners taught acid-base reactions had performed better academically compared to the learners who had their lessons in PowerPoint presentation and Teacher Based Demonstration experiment.

The scratch program made the learners to have better academic performance because of its interactiveness between the activities and among the learners themselves. Anna et al. (2018) supports that creating an online chemistry activities using laid down principles which learners can use at their own pace improves their academic performance. Therefore, this study created scratch program activity on titration wich was more engaging and the learners learnt practically how to conduct titration. As the scratch program was interactive, they learners collaborated and worked with one another on successfully completing the tasks given. For examples, learners were able to slow down or stop the titration process using the scratch program and start all over again. At the same time, the learners were able to perform the activities at their own pace. Alexious, Bouras and Giannaka (2005) supports that an educational virtual laboratory is suppose to meet the requirements of a real laboratory. Therefore, these purposiveful stops enabled the learners to appreciate the colour changes which takes place at the end point of titration. As a result, both attitudes and academic performance of the learners improved as the scratch program was used.

Furthermore, the scratch program which the researcher created on titration promoted the values, skills and knowledge as propounded by the Zambian school curriculum framework which in turn promoted the improvement in academic performance. This was because the scratch program had learning modalities described in the conceptual framework. One of the skills which the scratch program brought out at excursion is demonstration which promoted learner centred approaches. This promoted acquisition of concepts of acids and bases. Learners who were using the scratch program were able to demonstrate to one another on how titration was to be done using the scratch program created. As a result, the learners also gained the knowledge on using titration method to prepare soluble salts and perform easily the calculations on determining the concentration of both the titrate and titrant as compared to the PowerPoint Presentation method. The scratch program was a safe way of performing these activities on acid-base reactions hence the learners gained values of awareness of the dangers of acids and bases including applying safety rules in preparation of salts.

Scratch program promoted meaningful learning as in the conceptual framework through being wholly involved. As the learners were calculating the concentration of the titrant, there was a great need to correctly calculate the concentrations of the titrant. Besides, these learners were also collaborating and communicating with each other hence skills such as communicating and appreciating one another was enhanced as provided for in the zambian school curriculum. Therefore, the Zambian School Curriculum supports meaningful learning which was encompassed by the scratch program which was created on the titration. This brought about high retention rate on the part of the learners as they were wholly involved in the learning process.

Besides, the learners who were taught acid base reactions using teacher based demonstration experiment didn't perform because the had little hands on activities. This is supported by Arda et al.,(2005) who states that learners who were taught acid base reactions using computer aided instructions performed highest in computational knowledge because they were practising as well at their own pace at their homes.

5.5 Implications

The research findings produced implications that would be important in performing virtual laboratory activities using either the Scratch program or the PowerPoint presentation. If these implications are considered, it would be beneficial to the learners to enhance both their attitude and academic performance in upgraded secondary schools in Mongu district and other schools using either the Scratch program or PowerPoint presentation. Scratch program was useful especially when learners were imitating what the animation was performing was useful to perform titration experiments but the PowerPoint presentation could be used on titration experiements that were found anywhere as slides were just made. The implications are listed below as follows:-

1. Scratch program approach fostered a better attitude towards the learning of acid-bases reactions on performing titration experiments as compared to the PowerPoint presentation because all the principles of a multimedia learning technique were incorporated. Scratch program project enabled learners to actively participate more in the learning process as compared to the PowerPoint presentation. The learners who used the scratch program approach were more motivated because of learning by doing especially when coding was involved compared to the PowerPoint presentation.
2. There was a good academic performance rate by the learners who were taught using both the Scratch program project and PowerPoint presentation. However,the learners had better academic results when using the Scratch program as compared to the learners who were using PowerPoint presentations. Since learners enjoy watching and playing animations, it is therefore encouraged that scratch program can be used to teach the learners how to conduct titration experiments and solving the calculations that involve concentration so that the learners understand better how to calculate the concentration of the titrant.

5.6 Chapter Summary

This study showed that the learners who were taught titration experiments using Scratch program had a better improvement in both attitudes and academic achievement as compared to the group which was taught using PowerPoint presentation. It is therefore encouraged that the Scratch program be used to teach the learners titration so that the learners understand better how to balance chemical equations. In this regard, chemistry teachers are encouraged to be innovative as they integrate various technologies to enhance learning.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This chapter concludes the study on the effect of the virtual laboratory on the learners' attitude and academic performance on learning acid-base reactions to Grade 11 learners, a case of Upgraded Secondary Schools in Mongu district. The first part looks at research findings and conclusions. The second section provides the recommendations of the study where as the last part concentrates on future research endorsements.

6.2 Conclusion

This study is a revelation for the future of learners' understanding of acid-base reactions using scratch programs and PowerPoint presentations as digital modern teaching approaches. It achieved the objectives and answered the research questions raised using both qualitative and quantitative approaches.

It was discovered that when learning is done with the active participation of the learners in the learning processes, they acquire knowledge, skills and values which are necessary for effective and meaningful learning. Both scratch program and PowerPoint Presentation methods enabled the learners to be wholly involved in the learning process. The use of Information and Communication Technology skills is in line with the connectivism theory which is a theory in line with the digital world. This entels that when the learners are in class learning takes place and the process of learning can also continue even when there are outside the classroom.

In this regard, acquisition of skills is more prominent as the learners are involved in the learning process. Besides, when using the Information and Communication Technology(ICT) gardets, the teacher becomes more of a facilitator as compared of being a disseminator of knowledge and skills to the learners. The learners become more committed in the learning process because they are involved in the classroom activities. There is effective learning of the necessary skills and knowledge among the learners because of the process of learner centred approach which is enhanced by the introduction of both Information and Communication Technology(ICT) gadgets and also the skills acquired when using the gadgets.

In conclusion, both the Scratch project and PowerPoint presentation have proven to be invaluable tools in enhancing communication, creativity, and learning experiences. The

Scratch program, a beginner-friendly coding platform, offers an engaging way for individuals to learn fundamental programming concepts while creating interactive projects. On the other hand, PowerPoint presentations remain a staple in effective visual communication, enabling users to convey complex information through a combination of text, images, and multimedia elements. Throughout this exploration, it is evident that both tools have their unique strengths and applications that cater to various learning and communication needs.

Scratch program is superior to both PhET interactive simulation and PowerPoint presentation methods because of promoting conceptual learning where learners perceive different ideas as connecting concepts. This is in line with the scratch program where sprites and the"my blocks" are suppose to be linked together to create a video. As a scratch program is being created, conceptual materials need to be more clear to the learners in terms of order of material sequencing It enables learners to explain the meaning of concepts. As a result, scratch program would bring about meaningful learning.

The created titration scratch program included all the learning modalities of auditory, visual, kinaesthetic and tactile. Besides, it was interactive hence encouraged creativeness, computational thinking skills concepts, problem solving and logical thinking skills through dragging and dropping code blocks. Therefore, this study contributes to the body of knowledge the titration scratch program which can be used by teachers in delivering lessons on acid base reactions.

6.3 Recommendations

Following the results from this study, recommendations are made as below:-

1. From the learners' good academic performance and good exhibition of attitudes when using scratch program, the scratch program is recommended to be used by teachers when handling Science, Technology, Engineering and Mathematics study areas. Scratch program arouses and improves the learners' attitudes, interest, and participation which in turn improve the learners' academic achievement. This is brought about because of the scratch program has multimedia principles of auditory, visual, feeling(touch) and movement. This would enable all the learners to be met at their need point for effective learning to take place.

2. Teachers especially in upgraded secondary schools to consider integrating scratch program into their teaching of the Natural sciences subjects so that the learners can

learn both theory and practice. This will enhance knowledge, skills and values in a practical way. The skills which are improved effectively are problem-solving, critical thinking, collaboration and communication among the learners. Scratch not only introduces pupils to coding principles but also fosters logical thinking and creativity. Interactive projects created in Scratch could serve as dynamic learning resources, promoting active engagement and deeper understanding.

3. When teachers are using PowerPoint, the focus should be on improving visual literacy when creating presentations which involves using appropriate fonts, colours, images, and layouts to enhance the visual appeal and overall comprehension of the content. Additionally, incorporating data visualization tools and infographics can effectively communicate complex information to the learners especially games, animations and you tube videos being included.

4. When both scratch program and PowerPoint presentation are used by teachers, they should continuously seek opportunities to enhance their skills. For Scratch, this could involve tackling more complex coding challenges, while PowerPoint presentation might explore advanced features such as animations, transitions, and interactive elements.

In summary, the combination of Scratch and PowerPoint offers a dynamic duo for effective learning and communication. Embracing their respective strengths and applying the recommended strategies would lead to more engaging educational experiences and impactful presentations. As technology continues to evolve, adapting and innovating with these teaching and learning tools would ensure continued success in both educational and professional realms.

6.4 Direction for Future Research

In the educational field, the further exploration processes of all the subject concepts, theories and skills never end as always new information is added. As a result, the educational researchers and scholars always bear in mind that there is a huge task of finding possible solutions to the various problems in their field of study. It is the contention that demonstrates that if there is nothing amiss with a part of education, at that point, researchers ought to be investigating prospects of improving it before something goes wrong. As the findings, discussions and limitations have indicated, there was already something which needs to be included as for further study in this current study.

There is a great need to conduct more research in the area of improving the academic performance and attitudes of the learners in line with each challenge recognised as being a factor which is bringing down the learners' academic performance. Mostly, the learning process does not include the wholly participation of the learners in the learning process. Therefore, to make learning more effective, there is a great need to enable the classroom have teaching methods which are learner centred. This would result in learners being in charge of the learning process such that the skills and knowledge would be acquired. This would improve the learners' academic performance as well as learners' attitude as research findings would make the learning of worthwhile teaching methods would be.

The following are the areas of further research:-

1. More research in the area of scratch and coding so that the learners find coding a useful aspect of learning.
2. Analyse the factors contributing to less competence in multimedia among learners in the schools.

6.5 Chapter Summary

The chapter looked at the recommendations and conclusions of the study. A combination of scratch and PowerPoint offers a dynamic duo for effective learning and communication among the learners. Traditional teaching methods should be combined with the digital platforms to bring meaningful learning to the learners.

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APPENDICES

Appendix A: Interview

This interview seeks to gather information on attitudes towards acid-bases reactions. As a pupil who participated in the lessons, you are required to respond to all the questions on the interview schedule.

1. What did you like about the scratch program/PowerPoint Presentation method used in teaching acid-base reactions? Explain what you liked ?
2. What did you like about the scratch program/PowerPoint presentation method used when learning acid-base reactions after your class? State how you used it to answer your homework questions?
3. Explain how you found learning activities that involved scratch program/PowerPoint Presentation methods interesting?
4. Describe how beneficial the scratch program/PowerPoint Presentation method was to you?

Appendix B: Likert Scale

Please answer the questionnaire below honestly. Indicate whether you belong to the Virtual laboratory group or the lecture group by marking in the box next to the group name you belong to.

Scratch Program		PowerPoint presentation	

Read the statement and tick where you feel is correct for you. The initials in the questionnaire there mean SD-Strongly disagree, D-Disagree, U-undecided, A-Agree and lastly SA-Strongly Agree.

ITEMS	SD	D	U	A	SA
	1	2	3	4	5
I like titration experiment lessons					
I think titration is important to understand acid-base reactions.					
I can perform titration experiments					
I ask questions on titration whenever acid-base reactions are presented					
I think scratch program/PowerPoint Presentation method is not a good strategy of learning acid-base reactions.					
I am excited with activities that involve scratch program/PowerPoint presentation on acid-base reactions.					
I think other topics should be taught using scratch program/PowerPoint Presentation method.					
I think scratch program/PowerPoint Presentation method is not beneficial to me.					
I am excited with scratch program/PowerPoint Presentation methods used in teaching acid-base reactions...					
I feel delighted in acid-base reactions using scratch program/PowerPoint Presentation method.					
I like interacting with others when learning acid/base reactions.					
I participate actively in acid-base reactions lessons					
I lost interest in acid base reactions lessons.					

Appendix C: Measuring Attitudes and Participation

This Rubric intends to measure the attitudes and participation of the learners in scratch program, PowerPoint Presentation method and Teacher Based Demonstration Experiment Method. The highest score is 5 while the lowest score is 2. Depending on how the researcher observes the interaction and its correlation with the laid down guidelines, the researcher would award marks. The rubric is purely from an observatory point and it would give the qualitative analysis.

Rubric to measure attitudes and particpation in scratch program/PowerPoint Presentation method

Criteria	Excellent 5 points	Very good 3 points	Borderline 2 points	Poor 1 points	Score
Attitude	Students in the group consistently demonstrate to each other. All questions, responses and body language, are respectful and appropriate. Always demonstrate to,ask questions and responses given.	Demonstrates to, asks and responds to each other. Demonstrations Questions and responses are respectful and appropriate body language was exhibited.	Most demonstrations, questions and responses including body language were respectful with occasional negative tone. Does not always demonstrate, ask questions and no responses.	Demonstrations, Questions and responses including body language were consistently not respectful. Rarely demonstrates , asks questions and responds to others	
Participation	Students in the group always demonstrate, asks and responds to each other to solve the acid-base reactions in the lab correctly	Group members are woulding to demonstrate to each other when solving acid-base reactions during laboratory activity.	Each member attempts to demonstrate to the group to correctly solve acid-base reactions but some members interferes.	Members typically do not demonstrate to the group to perform an acid base reaction.	

Appendix D: Pre-Test

NATURAL SCIENCES DEPARTMENT

NAME OF A PUPIL:……………………………………SEX……….. CLASS……..

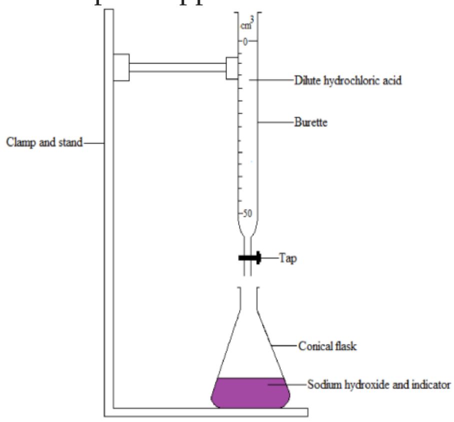
You are provided with:-

- ♣ 1M hydrochloric acid solution
- ♣ 1M sodium hydroxide solution
- ♣ Conical flask
- ♣ Pipette
- ♣ Burette
- ♣ Phenolphthalein indicator
- ♣ White tile
- ♣ Clamp and stand
- ♣ Electronic balance

In this task, you would quantitatively determine the concentration of an acid. Aqueous solutions of acids yield H^+ and OH^-. The particles react in a neutralization reaction according to the following equation: $H^+ + OH^- \rightarrow H_2O$

Method

1. Pipette 25cm^3 of sodium hydroxide into the conical flask and add 3 drops of phenolphthalein indicator. Indicate the colour of the indicator on the sodium hydroxide
………………………………………………………………………………………………
… ………………………………………………………………………………………… [1]
2. Fill the burette with hydrochloric acid
3. Place the conical flask under the spout of the burette
4. Set up the apparatus as shown below



5. Titrate in the usual manner until the end point. Carry out at least three titrations until you achieve consistent results. What is the colour at the end point?
………………………………………………………………………………………………
……………………………………………………………………………………………. [1]
6. Record your results in the table below

TITRATION NUMBER	**TRIAL 1**	**TRIAL 2**	**TRIAL 3**
Final reading(cm^3)			
First reading (cm^3)			
Volume of acid (cm^3)			
Tick the best titration results			

[12]

(a) Use the best titration results to find the average volume of the acid used

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………..…………………………………………………… [1]

(b) Why is it necessary to do three trials?

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

(c) Use the relationship, $M_AV_A = M_BV_B$, and the information collected in the titration and the balanced chemical equation to find the concentration of the hydrochloric acid in mol/dm^3

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(d) Describe the uses of netralisation reactionin every day

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[2]

[Total = 20marks]

Appendix E: Post-Test

NATURAL SCIENCES DEPARTMENT

NAME OF A PUPIL:……………………………………SEX………… CLASS……..

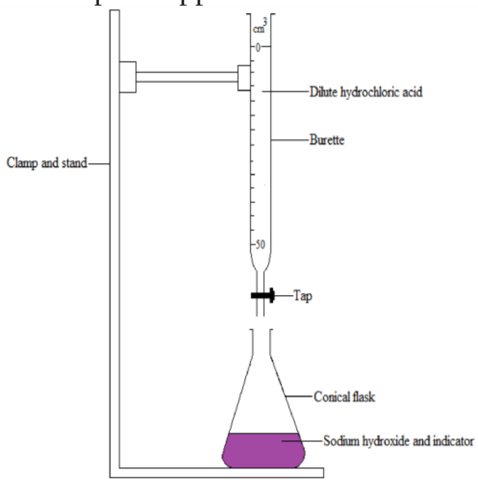
You are provided with:-

- ♣ 0.5M Sulphuric acid solution
- ♣ 0.5M Potassium hydroxide solution
- ♣ Conical flask
- ♣ Pipette
- ♣ Burette
- ♣ Phenolphthalein indicator
- ♣ White tile
- ♣ Clamp and stand
- ♣ Electronic balance

In this task, you would quantitatively determine the concentration of an acid. Aqueous solutions of acids yield H^+ and OH^-. The particles react in a neutralization reaction according to the following equation: $H^+ + OH^- \rightarrow H_2O$

Method

1. Pipette $25cm^3$ of Potassium hydroxide into the conical flask and add 3 drops of phenolphthalein indicator. Indicate the colour of the indicator on the Potassium hydroxide
……………………………………………………………………………………………
… …………………………………………………………………………………… [1]
2. Fill the burette with sulphuric acid
3. Place the conical flask under the spout of the burette
4. Set up the apparatus as shown below



5. Titrate in the usual manner until the end point. Carry out at least three titrations until you achieve consistent results. What is the colour at the end point?
……………………………………………………………………………………………
…………………………………………………………………………………………. [1]

6. Record your results in the table below

TITRATION NUMBER	TRIAL 1	TRIAL 2	TRIAL 3
Final reading(cm^3)			
First reading (cm^3)			
Volume of acid ($cm^{3)}$			
Tick the best titration results			

[12]

(a) Use the best titration results to find the average volume of the acid used

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………..……………………………………………………… [1]

(b) Why is it necessary to do three trials?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………………………… [1]

(c) Use the relationship, $M_AV_A = M_BV_B$, and the information collected in the titration and the balanced chemical equation to find the concentration of the Sulphuric acid in mol/dm^3

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………………………… [2]

(d) Describe how a farmer would make his acidic farm land to be fertile once again in order for maize to be cultivated.

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………[2]

[Total = 20marks]

Appendix F: Interview Transcription

This is an interview transcript for an interview with a Scratch program group member here referred as E1.

Interviewer: Welcome to this interview, you need to be free to express your opinion on what you are learning in class. This interview is being recorded and its purely for this exercise you are doing with scratch project. Once more please feel free and welcome.

E1:….Thank you

Interviewer: Which group are you belonging to?

E1: Learning titration using the scratch program

Interviewer: What did you like about scratch program method used in teaching acid-base reactions? Explain what you liked most.

E1: *Hmmmm……… we don't usually use computers to learn except when it's computer studies hence it was really good to use them for titration. Kikiki……All my friends wanted to play the scratch program videos on the computer to determine how titration is done hence each member of the group participated in viewing titration expriements using the Scratch Program app on the computers.Aaaa… As learners we were involved in the lessons so much………. that it made us continue solving problems related to titration even when it was not the periods for chemistry as long as the computer lab was free……. Sometimes until we are told to go away when its time to knock off*

Interviewer: What did you like about Scratch program method used when learning acid-base reactions after class.

E1: hahaha…. I was able to practice at home using the computer. At home we play games on the computer but after learning about scratch,……. Hmmmm I was able to learn on my own how titration is done whilst watching games and listening to the narrations on the concept of titration.

Interviewer: Explain how you found learning activities that involved scratch program methods interesting.

> *E1: scratch program was nice….. interesting as the coded animations showed the correct amount of acid and base to use to reach the equivalent point. …… I liked it as it was an interactive way of learning where all the members of the group were involved. It was good to visualise the concept of titration and perform calculations.*

Interviewer: Describe how beneficial the scratch program method was to you.

> *E1: hmmmm…….. the calculations which were difficulty to perform were made easier using coding hence I …… have learnt how well to conduct titration correctly plus my friends were helpful. What was difficulty hmmmmmm looks to be simple now*

Appendix G: Marked Pre-Test Script

05%

1/20

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION,
MATHEMATICS AND SCIENECE DEPARTMENT

NAME OF A PUPIL:.[redacted]..............SEX.....[redacted]........ CLASS..11 B...

You are provided with:-

- 1M hydrochloric acid solution
- 1M sodium hydroxide solution
- Conical flask
- Pipette
- Burette
- Phenolphthalein indicator
- White tile
- Clamp and stand
- Electronic balance

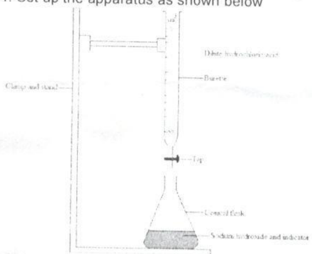
In this task, you will quantitatively determine the concentration of an acid. Aqueous solutions of acids yield H^+ and OH^-. The particles react in a neutralization reaction according to the following equation: $H^+ + OH^- \rightarrow H_2O$

Method

1. Pipette 25cm³ of sodium hydroxide into the conical flask and add 3 drops of phenolphthalein indicator. Indicate the colour of the indicator on the sodium hydroxide

....orenge... [1]

2. Fill the burette with hydrochloric acid
3. Place the conical flask under the spout of the burette
4. Set up the apparatus as shown below



5. Titrate in the usual manner until the end point. Carry out at least three titrations until you achieve consistent results. What is the colour at the end point? .... [1]

6. Record your results in the table below

TITRATION NUMBER	TRIAL 1	TRIAL 2	TRIAL 3
Final reading(cm³)	46 cm³		
First reading (cm³)	0. cm³		
Volume of acid (cm³)	46 cm³		
Tick the best titration results	✓		

[12]

no entries for trials 2 and 3

(a) Use the best titration results to find the average volume of the acid used

....46 cm³... [1]

(b) Why is it necessary to do three trials?

.... [1]

(c) Use the relationship, $M_AV_A = M_BV_B$, and the information collected in the titration and the balanced chemical equation to find the concentration of the hydrochloric acid in mol/dm³

.... [2]

(d) Describe the uses of netralisation reactionin every day

....[2]

[Total = 2]

Appendix H: Marked Post-Test Script

SCRATCH

[redacted]

The University of Zambia
School of Education
Mathematics and Science Department
Post Test

NAME OF A PUPIL: [redacted] INDEX. [redacted] CLASS. 11A

18/20 — 90%

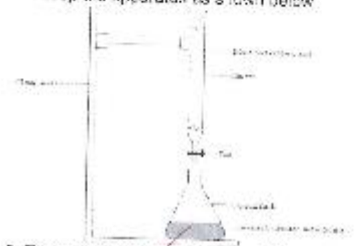
You are provided with:

- 0.5M Sulphuric acid solution
- 0.5M Potassium hydroxide solution
- Conical flask
- Pipette
- Burette
- Phenolphthalein indicator
- White tile
- Clamp and stand
- Electronic balance

In this task, you will quantitatively determine the concentration of an acid. Aqueous solutions of acids yield H^+ and OH^-. The particles react in a neutralization reaction according to the following equation. $H^+ + OH^- \rightarrow H_2O$

Method

1. Pipette $25cm^3$ of Potassium hydroxide into the conical flask and add 3 drops of phenolphthalein indicator. Indicate the colour of the indicator on the Potassium hydroxide
......orange ✓ (01) .... [1]
2. Fill the burette with sulphuric acid
3. Place the conical flask under the spout of the burette
4. Set up the apparatus as shown below



5. Titrate in the usual manner until the end point. Carry out at least three titrations until you achieve consistent results. What is the colour at the end point?
......Pink ✓ (01) .... [1]
6. Record your results in the table below

TITRATION NUMBER	TRIAL 1	TRIAL 2	TRIAL 3
Final reading (cm³)	13 ml	25 ml	20
First reading (cm³)	0.0 ml	13 ml	0.5 ml
Volume of acid (cm³)	13 ml	12 ml	15
Tick the best titration results			

(12) [12]

always be consistent with units

(a) Use the best titration results to find the average volume of the acid used
$\frac{(13+12+15)}{3}$ ml $= \frac{40}{3} = 13.4$ ml ✓ (01) [1]

(b) Why is it necessary to do three trials?
To be correct or bone accurate ✓ (01) [1]

(c) Use the relationship, $M_AV_A = M_BV_B$ and the information collected in the titration and the balanced chemical equation to find the concentration of the Sulphuric acid in mol/cm³
$MA = \frac{MB \times Vb}{VA} = \frac{0.5 \times 25}{13.4}$
$= 1.72$ mol/dm³ ✓ (02) [2]

(d) Describe how a farmer would make his acidic farm land to be fertile once again in order for maize to be cultivated.
To neutralised the soil ✗ [2]

[Total = 20marks]

Appendix I: Marked Likert Scale

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION,
MATHEMATICS AND SCIENECE DEPARTMENT

LEARNER'S ATTITUDE SCALE QUESTIONNAIRE (LIKERT SCALE)

Please answer the questionnaire below honestly. Indicate whether you belong to the Virtual laboratory group or the lecture group by marking in the box next to the group name you belong to.

Scratch Program	✓	Powerpoint presentation	

Read the statement and tick where you feel is correct for you. The initials in the questionnaire there mean SD-Strongly disagree, D-Disagree, U-undecided, A-Agree and lastly SA-Strongly Agree.

ITEMS	SD	D	U	A	SA
	1	2	3	4	5
I like titration experiment lessons					✓
I think titration is important to understand acid-base reactions.			✓		
I can perform titration experiments				✓	
I ask questions on titration whenever acid-base reactions are presented					✓
I think scratch program/powerpoint presentation method is not a good strategy of learning acid-base reactions.			✓		
Iam excited with activities that involve scratch program/powerpoint presentation on acid-base reactions.					✓
I think other topics should be taught using scratch program/powerpoint presentation method.				✓	
I think scratch program/powerpoint presentation method is not beneficial to me.			✓		
Iam excited with scratch program/powerpoint presentation methods used in teaching acid-base reactions..					✓
I feel delighted in acid-base reactions using scratch program/powerpoint presentation method.				✓	
I like interacting with others when learning acid/base reactions.					✓
I participate actively in acid-base reactions lessons			✓		
I lost interest in acid base reactions lessons.				✓	

Appendix J: Introduction Letter from DEBS

All Correspondence should be addressed
To the DEBS

In reply please quote

No: ....

REPUBLIC OF ZAMBIA

MINISTRY OF EDUCATION

DISTRICT EDUCATION BOARD SECRETARY
P.O BOX 910035
MONGU

6th January, 2023

The Headteachers
Malengwa Secondary School
Kanyonyo Secondary School
Imwiko Secondary School
Katongo Secondary School
MONGU DISTRICT

RE: INTRODUCTORY LETTER: MR. NICHOLAS SIBINDA

This serves to introduce to you Mr. Sibinda a student at University of Zambia who is visiting your school in order to carry out a research on ***' The effects of Virtual Laboratory on learners' achievement and attitude towards learning Acid-Based reactions among Grade Eleven learners'***

Kindly attend to him and agree with him on the best time this can be done in school without disturbing teaching and learning

Lisimba Ilutombi I.M
District Education Board Secretary
Mongu District

..rs/

REPUBLIC OF ZAMBIA
MINISTRY OF EDUCATION
DEBS
06 DEC 2023
MONGU DISTRICT EDUCATION
BOARD OFFICE
P.O. BOX 910035, MONGU.

Appendix K: Lesson Plans

DEPARTMENT OF NATURAL SCIENCES
LESSON PLAN

Name of school: Malengwa Secondary School

Grade: 11

Date: 23rd February, 2023

Subject: chemistry

Duration: 80 minutes

Topic: Acid, Base and Salts

Subtopic: Characteristics properties of Acids and bases

References:

- Chemistry book 3 by Kagoda silver pg 120
- Chemistry key points 68
- Chemistry Zumdahl and zumdahl pg 697

Teaching and learning materials: Clamp stand, methyl orange indicator, $NaOH_{(aq)}$,$HCl_{(aq)}$, Burette, pipette, funnel, white tile. Powerpoint presentation slides, work cards

Specific outcomes:

- Differentiate between an acid and a base
- Discuss the properties of acids
- Describe the properties of bases

Rationale: this lesson is on acids and bases will help learners to be able to identify acids and bases and it will also enable them to identify their uses. It is the first lesson in the series of six. The methodology to use are question and answer, group discussion and demonstration methods.

Pre-Requiste knowledge: items used for cleaning at home.

Key focus question: what are the characteristics of acids and bases?

Duration	Teacher's Activities	Learners' Activity	Content
Introduction 5 min	Tr. ask ppls to mention what they use at home for cleaning plates, disinfecting pit latrines. Tr. writes on the answers on the board Tr. asks ppls what is contained in some objects(lemon, ash) Tr. introduces the lesson on acids and bases	Ppls to mention soaps, ashes Ppls to define neutralisation reaction. Ppls observe the answers being written Ppls respond that a lemon contains an acid whereas ashes contain alkalis Ppls write the heading as acids and bases	Soap Detergents paste Lemon cleaning Acids alkalis
Lesson development	Tr. assigns learners to be in groups of four	Ppls are put in groups of four	Group 1 Define an acid

35 mins	Tr. asks learners to be collect work cards Tr. asks learners to write their responses on the work cards Tr. goes round the groups to look at what the groups are doing Tr. asks groups to present their answers Tr. makes corrections and explains the answers in details Tr. displays the pwerpoint presentations on the acids and bases	Ppls collect work cards Ppls write answers on the work cards Ppls in groups work on the answers to the tasks given Ppls are assisted with their work. Ppls present their answers Ppls write notes from the slides	Group 2 Write down the characteristics of acids Group 3 Define a base Group 4 Write down the characteristics of bases
30 mins	Tr. collects different samples of acids and alkalis Tr. adds distributes the acids and bases to learners in groups Tr asks learners to add drops of methyl orange to acids and bases. Tr. ask learners to write down their observation Tr asks learners to write present their work Tr. displays the slides on the colour changes of methyl orange Tr. displays a video on the colour changes on methyl orange	Ppls to observe Ppls receive the acids and bases Ppls collect droppers and methyl orange indicator Ppls add drops of methyl orange to acids and bases Ppls observe the colour change Ppls present their work Ppls writes notes from the slides Ppls observe the video and take notes.	In acid, methyl orange turns red while in alkali methyl orange turns yellow and in a neutral solution, methyl orange turns orange
Conclusion 10 minutes	Tr. asks each learner to explain anything they learnt in the lesson	Ppls explain any relevant concept learnt in the lesson	Acids, bases, Properties and indicator

Lesson evaluation: The learners were able to answer questions on the differences between acids and bases including the properties of both acids and bases. Some learners gave the colour changes correctly while others were not able to as they confused orange and red. These learners were corrected.

DEPARTMENT OF NATURAL SCIENCES
LESSON PLAN

Name of school: Malengwa Secondary School

Grade: 11 Date: 23rd March, 2023

Subject: chemistry Duration: 80 minutes

REPUBLIC OF ZAMBIA MINISTRY OF EDUCATION DEPUTY HEADTEACHER 23 MAR 2023 checked MALENGWA SECONDARY

Topic: Acid, Base and Salts

Subtopic: Preparation of soluble salts

References:

- Chemistry book 3 by Kagoda silver pg 120
- Chemistry key points 68
- Chemistry learners book G11
- Chemistry Zumdahl and zumdahl pg 697

Teaching and learning materials: Clamp stand, methyl orange indicator, $NaOH_{(aq)}$,$HCl_{(aq)}$, Burette, pipette, funnel, white tile. Powerpoint presentation slides, work cards

Specific outcomes:

- Define a neutralisation
- Perform a titration experiment
- Deduce the molarity of the acid

Rationale: The lesson will be on preparation of soluble salts. This will equip learners with the knowledge on how to prepare soluble salts through neutralisation reaction. It is the sixth lesson in the series of six. The methodology to use are question and answer, group discussion and demonstration methods.

Pre-Requiste knowledge: Learners already have already knowledge about soluble salts .

Key focus question: what are soluble salts?

Duration	Teacher's Activities	Learners' Activity	Content
Introduction 5 min	Tr. ask ppls to mention the types of reactions. Tr. to ask learners to define a neutralisation. and bases	Ppls to mention the types of reactions by raising their hands. Ppls define neutralisation.	Types of reactions • Neutralisation • displacement Neutralisation is a reaction where acids and bases of equal strength react to form salt and water only

Lesson development 10 mins	Tr. assigns learners to be in groups of four Tr. asks learners to be collect work cards Tr. asks learners to write their responses on the work cards Tr. goes round the groups to look at what the groups are doing Tr. asks groups to present their answers Tr. asks pupils to arrange the apparatus and reagents used for titration	Ppls are put in groups of four Ppls collect work cards Ppls write answers on the work cards Ppls in groups work on the answers to the tasks given Ppls are assisted with their work. Ppls present their answers Ppls arrange apparatus and reagents used for titration	All groups Apparatus Clamp stand Methyl orange indicator NaOH(aq), HCl (aq) Burette, pipette, funnel, white tile
10 mins	Tr. asks learners to pipette a 250cm^3 of NaOH(aq) and pour in the conical flask. Tr. asks learners to fill the burrette with HCl(aq)	Ppls to asks learners to pipette a 250cm^3 of NaOH(aq) and pour in the conical flask. Ppls to fill the burrette with HCl(aq).	Using a pipette collect 250cm^3 of NaOH(aq) and pour in the conical flask. Using a beaker pour using a funnel and fill the burette with HCl(aq)
10 minutes	Tr. asks learners to add 2 to 3 drops of methyl orange indicator into NaOH Tr. asks learners to observe the colour change	Ppls add 2 to three drops of methyl orange indicator into NaOH Ppls observe the colour change	Using a dropper add 2 to 3 drops of methyl orange indicator into NaOH(aq) in the conical flask NaOH changes colour from clear to yellow
10 minutes	Tr. asks ppls to titrate the acid into the base until the colour change is observed Tr. asks pupils to state the colour change	Ppls titrate the acid into the base Ppls state the colour change at end point	Titrate the acid into the the base until the end point is reached At the end point, the colour changes from yellow to orange
30 minutes	Tr. asks pupils to repeat the experiments three times Tr. asks pupils to record their results in the table	Ppls repeat the experiments three more times Ppls record the results in the table given	Record the results in the table |	1	2	3
V1			
V2				

Lesson evaluation: The learners performed the titration experiment well. The process of pipetting was done well except their some pipette fillers were not working well. The apparatus and reagents were arranged properly except that some droppers were defective. The volume obtained at first were too wide but other trials were almost ok.

DEPARTMENT OF NATURAL SCIENCES
LESSON PLAN

Name of school: Kanyonyo Secondary School

Grade: 11

Date: 20thJanuary, 2023

Subject: Chemistry

Duration: 80 minutes

seen / approved

Topic: Acid-Base-Scratch Program

Subtopic: Creating a simple scratch program

References:

- Chemistry book 3 by Kagoda silver pg 120
- Chemistry key points 68
- Chemistry Zumdahl and zumdahl pg 697

Teaching and learning materials: Computers, scratch program software

Specific outcomes:

- Open the scratch software
- Demonstrate the various aspects of the scratch program
- Create a simple scratch program

Rationale: this lesson is on scratch program which will help learners to be able to identify the various aspects of the scratch program and create a simple scratch program. It is the first lesson in the series of six. The methodology to use are question and answer, group discussion and demonstration methods.

Pre-Requiste knowledge: Creation of videos using scratch program.

Key focus question: what are the various aspects of creating a scratch programs?

Duration	Teacher's Activities	Learners' Activity	Content
Introduction 5 min	Tr. ask ppls how the make animations of pictures. Tr. introduces the scratch program Tr. asks ppls to write the definition	Ppls state that the pictures are joined using a software and some times music is added Ppls copies what the tr. writes on the board.	Animations made using the software Scratch is a high level block based visual programming language used as an educational tool.
Lesson development 35 mins	Tr. assigns learners to be in groups of four Tr. asks learners to be collect work cards Tr. asks learners to double click on the scratch program application to open it.	Ppls are put in groups of four Ppls collect work cards Ppls in groups double click on the scratch program to open it.	All Groups Double click on the scratch program application to open it. Displayed on the left top corner. • Code(Script)

	Tr. asks ppls to press on create button. Tr. asks ppls what features can be seen on the top left corner Tr. asks ppls to state what features are displayed on the top right side. Tr. asks ppls to press on the code Tr. asks ppls to mention what has been displayed Tr. asks ppls to discuss the functions of the displayed features from code	Ppls to open the application Ppls press on create button. Ppls mention what is displayed on the top right corner. Ppls press on the code on the left hand side top Ppls mention what is displayed when the code is displayed Ppls discuss the functions of the displayed features of the code	• Costume • Sound Displayed on the top right corner • Green flag • Orange polygon When Code is pressed it brings in the following:- Motion: used for the movement of the sprites. Looks: controls how the sprites looks or displayed Sound: controls both embedded and recorded sounds as produced by the sprite. Events: controls the timings of the sprite's activities during the program My blocks: creates new blocks which matches the sprites and enables them to be manipulated.
30 mins	Tr. asks ppls to press on stage Tr asks ppls what has happened to custome Tr. asks learners to press on back drop and chose the background Tr.asks learners to press on code and press the motion button Tr. asks ppls to select the motion blocks for the movement of the sprite Tr asks ppls to select other three blocks with different directions Tr. asks ppls to press on sound and record any sound	Ppls press on stage Ppls state that costume has been replaced by backdrops Ppls press on backdrop and chose the background. Ppls press on code and press the motion button Ppls select the motion block for the movement of the sprite Ppls select blocks with different directions Ppls press on sound and record any sound Ppls press on events and choose the forever block	When stage is pressed, it replaces costume with back drops. Back drop brings the background Motion button brings on the movement blocks Setting the time in seconds when the sprite moves Blocks with different direction sets the motion of the sprite in different directions The sound block records the sound and its timing

	Tr asks ppls to press on events. Tr asks ppls to choose the green flag to start the animations when pressed	Ppls choose the green flag to start the animations	Ppls choose the green flag as to start the scratch program
Conclusion 10 minutes	Tr. asks ppls to press on the green flag Tr. asks ppls to observe the movement of the sprite Tr asks ppls to make a new simple scratch program	Ppls press on the green flag Ppls observe the movement and sound of scratch Ppls make a new simple scratch program	Green flag starts the scratch program Movements of the scratch are observed

Lesson evaluation: Most of the learners were able to create simple scratch program using the embedded sprites. The learners worked in groups actively.

DEPARTMENT OF NATURAL SCIENCES
LESSON PLAN

Name of School: Kanyonyo Secondary School

Grade: 11

Date: 28th January, 2023

Subject: chemistry

Duration: 80 minutes

Seen / approved

Topic: Scratch Program

Subtopic: Creating a titration scratch program

References:

- Chemistry book 3 by Kagoda silver pg 120
- Chemistry key points 68
- Chemistry Zumdahl and zumdahl pg 697

Teaching and learning materials: Computers, scratch program software

Specific outcomes:

- Upload sprites for titration experiment
- Create 'my blocks' matching the sprites for titration experiment
- Create a scratch program on titration experiment

Rationale: this lesson is on scratch program on titration which will help learners to be able to identify and build an experiment from the sprites and blocks using the scratch program. It is the second lesson in the series of six. The methodology to use are question and answer, group discussion and demonstration methods.

Pre-Requiste knowledge: Creation of titration experiment using scratch program.

Key focus question: How to create a titration experiment using a scratch programs?

Duration	Teacher's Activities	Learners' Activity	Content
Introduction 5 min	Tr. ask ppls to demonstrate the simple scratch program made. Tr. asks learners experiments which they can do with scratch program Tr. asks ppls to write the definition of titration	Ppls demonstrate the scratch program made Ppls state the experiments which can be done using scratch program. Ppls write the definition of titration as an experiment	Experiments to be done using scratch include 1. Electrolysis 2. Diffusion 3. Titration
Lesson development 45 mins	Tr. assigns learners to be in groups of four Tr. asks learners to upload the downloaded titration apparatus and reagents	Ppls are put in groups of four Ppls upload the titration apparatus and reagents as sprites	All Groups Titration apparatus and reagents are uploaded as sprites and named. Stage gives the backdrops gives the

	Tr. asks learners to press on the stage Tr. asks learners to press on the backdrops. Tr. asks ppls to choose the board under the stage Tr asks learners to choose the 'my blocks' which sets the titration together. Tr. asks ppls to press on sound. Tr. asks ppls to record a narration of how titration experiment is done Tr. asks ppls to select looks to change the colour code in basic solution. Tr. asks ppls to select a block which indicates some fluid movement in the burette Tr. asks ppls to select the colour change at end point Tr. asks ppls to make a narration on the colour change at end point Tr. asks ppls to select events Tr. asks learners to select the 'forever' Tr. asks learners to select the 'flag' to start the scratch program	Ppls press on the stage. Ppls press on the backdrops. Ppls select the black board under the stage Ppls select the blocks which set up the titration experiment together. Ppls asks learners to press on sound Ppls record a narration of how the titration is done Ppls select looks under code and select colour yellow Ppls select the movement block to show the drops of the acid into the basic solution Ppls select the colour change at end point Ppls select the sound and record the narration of colour change at end point Ppls select events Ppls select the 'forever' button Ppls select the green flag to start the scratch program	background of the scratch The black board was selected The blocks sets the titration experiment Pipette is used to measure the fixed volume of the solution. Burrette used to measure the accurate volume of the solution. In basic solution, the colour of the indicator is yellow while in acidic medium the colour of the indicator is red Drops of an acid enter into the basic solution in the conical flask Orange colour is indicated at end point Events determine the timings of blocks Forever button makes the scratch program to run continously The green flag runs the scratch program
20 mins	Tr. asks ppls to demonstrate their work Tr asks ppls to observe and ask questions Tr. asks learners to correct their work	Ppls to demonstrate their work Ppls observe and ask questions.	Demonstration of the scratch program as done by the groups.
Conclusion 5 minutes	Tr. asks ppls to demonstrate how scratch can be used to perform titration	Ppls to demonstrate how scratch can be used to perform titration	Demonstration of how titration can be done using scratch.

Lesson evaluation: The learners created the simple situations using the downloaded sprites and the 'my blocks' successfully.

Appendix L: Ethical Clearance

THE UNIVERSITY OF ZAMBIA
SCHOOL OF EDUCATION

Telephone: 291381
Telegram: UNZA, LUSAKA
Telex: UNZALU ZA 44370

PO Box 32379
Lusaka, Zambia
Fax: +260-1-292702

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Date...30th SEPTEMBER, 2022.........

TO WHOM IT MAY CONCERN

Dear Sir/Madam

RE: FIELD WORK FOR MASTERS/ PhD STUDENTS

The bearer of this letter Mr./~~Ms~~...NICHOLAS PIBINDA...Computer number...ED 2200115.......is a duly registered student at the University of Zambia, School of Education.

He/~~She~~ is taking a Masters/PhD programme in ...VIRTUAL LABORATORY.......

The programme has a fieldwork component which he/she has to complete.

We shall greatly appreciate if the necessary assistance is rendered to him/her/.

Yours faithfully

THE UNIVERSITY OF ZAMBIA
ASSISTANT DEAN (PG)
30 SEP 2022
SCHOOL OF EDUCATION
P. O. BOX 32379, LUSAKA

Bibian Kalinde (Dr)
ASSISTANT DEAN POSTGRADUATE STUDIES- SCHOOL OF EDUCATION

cc: Dean-Education
Director-DRGS

THE UNIVERSITY OF ZAMBIA

DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

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

APPROVAL OF STUDY

IORG No. 0005376
HSSREC IRB No. 00006464

30th September, 2022

REF NO. HSSREC-2022-SEPT. 011

Nicholas Sibinda
The University of Zambia
School of Education
Department of Mathematics and Science,
P.O. Box 32379
LUSAKA

Dear Mr. N. Sibinda

RE: "THE EFFETCS OF VIRTUAL LABORATORY ON LEANERS' ACHIEVEMENT AND ATTITUDE TOWARDS LEARNING ÁCID - BASE REACTIONS AMONG GRADE ELEVEN LEARNERS: A CASE OF UPGRADED SECONDARY SCHOOLS IN MONGU DISTRICT"

Reference is made to your submission of the protocol captioned above. The HSSREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

REVIEW TYPE	ORDINARY REVIEW	APPROVAL NO. HSSREC-2022-AUG-015
Approval and Expiry Date	Approval Date: 30th September, 2022	Expiry Date: 29th September, 2023
Protocol Version and Date	Version - Nil.	29th September, 2023
Information Sheet, Consent Forms and Dates	☐ English.	To be provided
Consent form ID and Date	Version - Nil	To be provided
Recruitment Materials	Nil	Nil
Other Study Documents	Questionnaire.	
Number of Participants Approved for Study		

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

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to HSSREC within 5 days.
- All protocol modifications must be approved by HSSREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to HSSREC within 5 working days.
- All recruitment materials must be approved by HSSREC prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. HSSREC will only approve a study for a period of 12 months.
- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to HSSREC.
- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by HSSREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled "late submissions" and will incur a penalty fee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.
- Every 6 (six) months a progress report form supplied by The University of Zambia Humanities and Social Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.
- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO), both HSSREC and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.
- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.
- Filing a closing report (rather than just letting your approval lapse) is important as it assists HSSREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.

- A reprint of this letter shall be done at a fee.

- All protocol modifications must be approved by HSSREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by HSSREC before they can be implemented.

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

On behalf of HSSREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,

Dr. J. I. Ziwa

DR. J. I. Ziwa

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

cc: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies