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BACHELOR OF SCIENCE HONOURS DEGREE IN CHEMISTRY

THE EFFECTIVENESS OF USING ICT IN THE TEACHING AND LEARNING OF CHEMISTRY AT CHAMANHANZVA HIGH SCHOOL IN CHIVI DISTRICT.

BY

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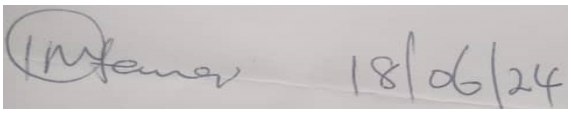
SIGNED: 

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DEDICATION

I dedicate this dissertation to my family for their assistance and moral support throughout my studies in this course.

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ABSTRACT

This study aimed to investigate the effectiveness of ICT in the teaching and learning of ordinary level Chemistry. The research used the qualitative research paradigm and the phenomenological research design. A purposive sampling procedure was used for this study because the researcher wanted the sample well represented and to obtain rich information from participants of diversified backgrounds. Research data for the study was collected through interviews and focus group discussions. The sample consisted of twenty participants who were male teachers and female teachers, Form 3 and Form 4 boys and girls. Findings from the research revealed that there is a low level of utilisation of ICT in the school. This study revealed that there are hindrances from the pupils, teachers and the school to using ICT in teaching Chemistry at Ordinary Level of education. In terms of the effects of ICT on students' engagement, understanding, and performance in Chemistry the research revealed negative and positive impacts. Positive effects noted were an increase in pupils' performance resulting from the change of attitude and perceptions of pupils towards Chemistry and an improvement in lesson attendance. ICT was also hailed for promoting a learner-centred approach to learning. Moreover, the research findings also reveal the pupils developed creativity through the use of ICT gadgets in learning Chemistry. In line with the research findings, the study recommends that schools and stakeholders should support Chemistry learning materially and financially. Both pupils and teachers need ICT gadgets and an internet connection. Other key recommendations include curriculum improvement to allow full integration of ICT in Chemistry lessons. The research further encouraged schools to offer opportunities to pupils and teachers teaching Chemistry to familiarise themselves with real-life applications of Chemistry in industries, pharmacies and places where there is applied Chemistry. The research suggested further study into gamified learning concepts for Ordinary-Level classes and the effectiveness of virtual laboratories.

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CHAPTER 1
INTRODUCTION

1.1 Introduction to the study

Chemistry plays a pivotal role in the everyday lives of people. Various sectors of society hinge on Chemistry. Health and medicine sectors find their breath in the field of Chemistry, food and nutrition, environmental protection, the construction industry and many other fields. Equipping pupils with chemistry education means ensuring the continuity of the above-mentioned fields of human lives.

Chemistry teachers face a plethora of challenges in trying to give effective instruction to pupils in this potent subject for pupils to get a high-quality chemistry education. Challenges faced by instructors in public schools include an acute shortage of teaching and learning resources that are required for effective instruction, limited time of instruction and low student motivation.

The use of ICT has a very high potential to address some of the challenges which the instructors are facing in teaching Chemistry. The use of ICT seems to be a hub for providing teachers with access to new resources and teaching strategies for engaging and motivating students to take Chemistry as a curriculum subject. This current study aims to explore the effectiveness of using various ICT tools in the teaching and learning of Chemistry at ordinary level education in Zimbabwean secondary schools.

As such this chapter offers an introduction to the study of the effectiveness of the use of ICT tools in the teaching and learning of ordinary level Chemistry in secondary schools. Chapter 1 looks at the brief historical background of the use of ICT in the teaching and learning process. It also presents the statement of the problem, the significance of the study, the purpose of the study, the aim of the research, research objectives and assumptions. Physical and conceptual delimitation of the research are given in this chapter as well as the limitations of the study, key terms are defined and the organisation of the study.

1.2 Background of the study

The use of ICT in the teaching of science subjects seems to be providing pupils with important opportunities for learning and operating in this information age for both teaching and communication. ICT is considered the foundation stone of the contemporary world (UNESCO Institute for Statistics, 2015). The introduction of Education 5.0 has witnessed a surge in the integration of ICT in the teaching and learning process through the concepts of research and innovation. A growing body of knowledge shows that the use of ICT-based learning plays a significant role in the science education system (Dori et al., 2013).

ICT stands for Information and Communications Technology. It is an umbrella term which describes the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system. It encompasses an assortment of technologies and equipment which include computers, networks, radios, and satellite systems, as well as services like video conferencing and distance learning (Wikipedia, 2024).

The teaching of Chemistry among other science subjects using digital technologies involves the use of a variety of devices such as computers, tablets, smartphones, and various online platforms as well as a wide range of software (Bingimlas, 2009). The underlining idea of the use of ICT in teaching and learning is that ICT is a key enabler of innovation, research and industrialisation which Education 5.0 is driving.

Researchers believe that ICT helps to make complicated things simple to comprehend adding to real learning and facilitating higher-order learning and thinking (Samphina Academy, 2022). Computers started to be placed in schools in the 1980s and researchers concur that ICT has helped to improve teaching and learning in the classroom across the curriculum through the improvement of communication between teachers and pupils (Bingimlas, 2009).

Existing literature attributes some pupils' enhanced academic achievement to the use of ICT. There are programs like Computer Assisted Instruction (CAI) which are believed to offer more learning time to pupils than conventional learning time and stimulate critical thinking (Samphina Academy, 2022). Researchers and theorists also assert that ICT can help to enhance teachers' pedagogical practice.

1.3 Purpose of the study

The main purpose of this study is to find out the effectiveness of information communication and technology (ICT) in the teaching and learning of Ordinary Level Chemistry in the Chivi District of Masvingo Province.

1.4 Statement of the problem

The past few decades have witnessed a rise in the use of ICT in the teaching and learning of science education and other curriculum areas. This information and technology revolution has paraded the development and implementation of innovative teaching and learning of science subjects. ICT has reduced the burden of teaching and learning through the use of computers and the internet.

Despite the good opportunities offered by ICT in the secondary education sector, there is a lack of evidence to support the claim that the use of ICT in the teaching of Chemistry in

secondary schools is effective in terms of pupils' learning outcomes and academic achievement. Whilst there is a consensus that ICT is beneficial in teaching and learning, there is a need for more empirical evidence to demonstrate its effectiveness in the teaching of Chemistry specifically. This research aims to address some gaps in the reviewed literature which highlighted some barriers militating against the effectiveness of ICT including teachers' knowledge, and availability of ICTs among others. Consequently, the study purports to find possible solutions to the potential challenges.

1.5 Research Aim

This study aimed to investigate the effectiveness of using Information and Communication Technologies (ICT) in teaching and learning Chemistry at Chamanhanzva High School in Chivi district.

1.6 Research Questions

Based on the research aim, here are three relevant research questions:

1. What is the current level of ICT utilization in Chemistry teaching at Chamanhanzva High School?
2. How does ICT impact student engagement, understanding, and performance in Chemistry?
3. What are the best practices and recommendations for effective ICT integration in Chemistry education?

1.7 Research objectives

The objectives of this study were as follows:

1. To assess the current level of ICT utilization in Chemistry teaching at Chamanhanzva High School.
2. To investigate the effects of ICT on student engagement, understanding, and performance in Chemistry.
3. To identify best practices and recommendations for effective ICT integration in Chemistry education.

1.8 Assumptions of the study

It was assumed in this study that:

1. Pupils who have access to ICT resources in Chemistry classes have better positive learning outcomes compared to those who do not have access to ICT resources.
2. Teachers who are proficient in the use of ICT tools effectively use them to obtain improved learning outcomes and high academic achievement for pupils.

3. The benefits of using ICT tools in teaching Chemistry outweigh the potential challenges or barriers to their use.

1.9 Significance of the study

It is deemed that this study may benefit the following groups of people:

Pupils: may have increased understanding of how ICT tools can be used to improve their academic achievement in Chemistry

Educators/ Teachers: would develop and share with others the best practices for using ICT tools in the teaching and learning of Chemistry

Schools: May develop some degree of tolerance to the use of smartphones and other ICTs on school premises by pupils.

Secondary Education Sector: Increased awareness and conscientisation of the benefits and challenges of using ICT in Chemistry lessons would improve teaching practice for Chemistry as a curriculum subject at Ordinary Level.

Moreover, the knowledge of ICT in Chemistry lessons may stimulate increased equity in the access to educational resources, thus it promotes inclusivity as pupils from different socio-economic backgrounds would have equal access to ICT tools in the school system.

Policy Makers: and curriculum planners would be aware of the numerous possibilities of using ICT tools in the teaching and learning process which may help design and implement learning activities that support various learning styles. Plans may be developed to equip teachers and students on how to use ICTs.

Educational Researchers: The findings of this study may provide literature to other educational researchers and add to the existing body of knowledge leading to enhanced knowledge of ICT in the system of secondary education.

1.10 Delimitation of the study

Geographically, the study was carried out at Chamanhanzva High School in the Ward 2 area of Chivi District of Masvingo Province in Zimbabwe. Conceptually, much focus of this study was placed on the teachers' and pupils' perceptions of the effectiveness of ICT tools in teaching and learning of Ordinary Level Chemistry in public schools.

1.11 Limitations of the study

Several limitations of this study can be acknowledged. Despite the strengths which the research had, there are critical issues which almost posed potential limitations to this study. Firstly the

researcher faced time constraints. Since the researcher is a full-time teacher and a part-time university student at the same time, there was limited time to collect data, analyse and compile a research report. The researcher countered this by making use of a research assistant to help with data gathering. There was a potential limitation of financial constraint, the researcher self-sponsored the study. To make sure the study flowed well the researcher budgeted well for the study activities which included financing the process of data collection and employing a competent research assistant. Moreover, there was a high likelihood of a lack of cooperation from fellow teachers and pupils. The researcher sought a clearance letter from the education officials and presented an introductory letter from Bindura University. The researcher also assured confidentiality to all respondents.

1.12 Definition of terms

ICT: Information and Communication Technology (ICT) refers to various digital and technological gadgets which are widely used in the field of education including computers, the internet, and electronic delivery systems such as radios, televisions, and projectors among others.

Perceptions: In this study, perceptions refer to the views which pupils and teachers hold about the use of ICT tools in schools.

Barriers: This refers to constraints or limitations which hinder the use of ICT tools in secondary school systems.

Science education: in this study science education refers to the teaching and learning of any science subject in a secondary school.

Effectiveness: this term shall refer to the positive and/ or negative impact of ICT gadgets in secondary schools.

Chemistry: Refers to the curriculum subject of Chemistry at the ordinary level (form 3 to form 4) of education in Zimbabwe.

1.13 Organisation of the study

Chapter one consists of the introductory part of the study which includes the background of the study, the statement of the problem, the research aim and the objectives of the research. It also presents the delimitation of the study, limitations of the study and definitions of key terms of the study.

Chapter 2 will focus on the review of related literature related to this study and the theoretical framework for the study. Chapter 3 will present the research methodology for the study. Chapter 4 centres around the research findings, thus data presentation, analysis and discussion of the research findings comparing with previous research findings. The fifth chapter consists of a summary of the findings, conclusions and recommendations based on the findings of the research.

1.14 Chapter Summary

Chapter One focused on the historical background of the use of ICT tools in the secondary education system. It also presented the statement of the problem, purpose of the study, research objectives, assumptions, and significance of the study. Physical and conceptual delimitation of the research were given in this chapter as well as the potential limitations which are deemed to affect the study, key terms were also defined in this chapter. Chapter two will review the related literature.

CHAPTER 2
RELATED LITERATURE REVIEW

2.1 Introduction

This chapter will focus on reviewing the literature available on the use and impact of ICT in teaching and learning. The review begins by giving a brief historical background of ICT in education. It draws on research and scholarship on ICT in the sector of education. Drawing from previous research, the chapter will explore the effectiveness of using ICT in teaching and learning chemistry in secondary schools. The literature review further explores the level of utilisation of ICT in secondary schools. An attempt is made to understand the policies governing the use of ICT in schools. The importance and challenges of using ICT in schools are also explored from previous literature. Chapter 2 also presents the effects of ICT on student engagement, understanding and performance. The best practices for the effective use of ICT in Chemistry education are also outlined as presented in the reviewed literature. The chapter also presents a theoretical framework, thus the theories propounded on the use of ICT in schools will be presented. Knowledge gaps will be explored on concepts presented in this chapter as justification for carrying out the research.

2.2 Definition of ICT

ICT can be defined as anything which allows people to get information, to communicate with others, affecting the environment using electronic or digital equipment (Alev, 2003).

2.3 Brief background of ICT in secondary schools

The history of the evolution of the use of digital technologies in the system of education has gained a lot of ground in the 21st century. ICT has gained ground as an area of study and as a research tool. This has led to educational institutions racing to secure computers and internet connectivity. The educationists aimed to make sure that ICT acts as a source of information, study tool and support for teaching and learning (Gil-Flores et al., 2017).

Computers were first introduced into the classrooms in the 1980s for basic digital literacy for students and computer-assisted learning (Hogenbirk, 2020). The internet and multimedia were introduced in the 1990s for accessing and sharing information which helped to transform the teaching and learning environment. In the 2000s, ICT was introduced into the curriculum as a subject and research tool. During this phase, computer studies were introduced into African countries (Kaunda et al., 2020). From 2010 onwards there was a new concept of smart classrooms, the use of whiteboards for learning and advancement towards digital literacy (UNESCO, 2023). The 2020s witnessed a phase of shifting of ICT towards personalised learning and online education which was accelerated by Covid-19 (Hogenbirk, 2020).

2.4 Level of the utilisation of ICT in secondary schools

2.4.1 Availability of ICTs in secondary schools

A growing body of knowledge has shown that the effectiveness or impact of ICTs in schools depends on the availability of resources. Previous educational research in reviewed literature shows that the use of ICTs has raised the standards of teaching and learning in private and public schools. Research affirms that ICT tools broaden the opportunities for teaching and learning for students and teachers (Odhiambo, 2018). Modern pedagogics show that the use of ICT influences how education is delivered by improving the quality of teaching and learning for the benefit of the learners (Mangwaya et al, 2019). There is a wide range of ICT products which can be used in schools. These include; computers, projectors, interactive whiteboards, smartphones, the internet and many others which enhance teaching and learning as articulated by Petry & Moss (2019). The availability of these resources during teaching and learning time gives pupils a competitive advantage when sitting for summative exams as Belay et al (2020) argued. Molotsi's research in the Bojanala District found that schools had very few laptops and a single projector per school and teachers were reluctant to use them (Molotsi, 2022). A recent study by the European Commission et al (2019) concluded that in Estonia, Lithuania, Latvia and Finland there was a relatively high use of ICT in schools because of the policy of Bring Your Own Device (BYOD). This current study would like to investigate the availability of ICTs at Chamanhanzva Secondary School and if there is knowledge of the use of ICT gadgets by teachers and pupils specifically in the subject of Chemistry.

2.4.2 Teachers' and pupils ICT literacy

Belay et al (2020) found that teachers were trained to use ICT tools but the unavailability of the resources affected them as shown by a study in Zimbabwe which differs from the case in Bojanala. Furthermore, the research by Ncube (2017) established that the majority of pupils in Zimbabwe could use ICT gadgets very well. In Eritrea, resources were available for teaching and learning computers as a subject not for research purposes as Belay (2020) found. As such pupils had not yet embraced ICT and they were unlikely to use the ICT tools. This research wanted to establish the ICT literacy of both pupils and teachers at Chamanhanzva in dispensing knowledge in the field of ordinary level chemistry.

2.4.3 Access to the internet

Various studies have credited the internet as a master stroke ICT tool for enriching teaching and learning resulting in the generation of new information and problem-solving among pupils (Cohen et al., 2018). Researches done around the period of 2015 and before in Southern Africa show that internet access was limited as Chitiyo and Muwana (2018) contend. In the sub-

Sahara, most countries had limited access to the internet in schools and homes, especially in rural areas resulting in limited information literacy as Odhiambo (2015) opined. This limited access meant that the teachers could not use it for content delivery and students could not use the facility when they needed it even outside school for research purposes. Contrary to this, in Europe, pupils reported using the internet at least once per week for learning purposes and the number of pupils who used the internet at school was high (European Commission et al., 2019). It was the prerogative of this study to find out the availability of the internet at schools and pupils' homes and measure how it would impact the teaching and learning of ordinary level Chemistry.

2.4.4 ICT Policy in schools

There exists a considerable body of literature on ICT policies in countries of southern Africa which highlighted that some countries have no school ICT policies. Reviewed literature showed that there are no policies to guide the use of ICT in schools in many countries (UNESCO Institute for Statistics, 2015). Document analysis revealed that schools lacked guidance in the awareness and use of ICT resources (Molotsi, 2022). Vast bodies of knowledge argue that government and school policies should provide schools with the minimum acceptable infrastructure for ICT, including stable and affordable internet connectivity and security measures such as filters and site blockers (UNESCO, 2023). In 1999 the Nziramasanga Commission recommended the use the use of ICT in teaching and learning. Zimbabwe then adopted the National ICT policy in 2005 which saw the promotion of the use of ICT in pedagogical practice in educational institutions. The then President of Zimbabwe Cde RG Mugabe launched a programme of equipping schools with computers and related materials which resulted in many schools and tertiary institutions benefiting from the programme (Musarurwa, 2011).

2.4.5 Challenges in the use of ICTs in schools

Previous studies by the European Commission et al (2019) have shown some perceived challenges in the use of ICT in schools as summarised into three broad categories. The most interesting challenge raised is equipment-related obstacles, thus shortage or unavailability of computers, tablets, computers not connected to the internet, lack of interactive whiteboards, and computers available but not serviced (Bingimlas, 2009). Another broad challenge pinned is the lack of adequate pedagogical skills of teachers to deliver lessons using ICT, thus lack of teacher competency (Bingimlas, 2009). The third challenge observed is an attitude-related obstacle which includes; the resistance of parents; the resistance of teachers; lack of interest of

teachers; no or unclear benefit to using ICT for teaching; and the use of ICT in teaching and learning not being a goal in the school. These views are in unison with previous research by UNESCO (2015). This research wanted to find out the nature of challenges related to the utilisation of ICTs at Chamanhanzva Secondary.

2.5 The importance of ICT in teaching and learning of Chemistry

There is a growing recognition of the many different ways that ICT is effectively contributing to the education system. The literature that was reviewed presented the following importance of ICT in Chemistry education.

2.5.1 ICT in the Chemistry Classroom

ICT can play various roles in the teaching and learning processes and after school. Several studies suggest that teaching pupils using ICT prepares pupils for the competencies needed for the workplace in the 21st century (Bingimlas, 2009). In Chemistry as a curriculum subject, there are some areas where ICT has been shown to have a positive impact on the school through concepts like an increase in pupils' motivation and knowledge in the curriculum subject. ICT is also deemed to reduce face-to-face teaching and learning in the classroom whilst focusing more on pupils' individual needs. There are many topics in Chemistry which can be taught easily using ICT. These include the calculation of molar refractivity, surface tension, Index of refraction, density, polarizability, editing of molar structure (2D and 3D), and IUPAC Nomenclature (Msafiri et al., 2023).

2.5.2 ICT in the workplace

ICT has helped to design software tools and programmes for chemistry teachers and researchers. Gupta (2023) has listed various Software for Chemists including ChemDraw which is a drawing tool used for chemistry research. ChemDoodle is another advanced drawing tool to show lone electrons, pairs of electrons, and arrow notation of bonds. ChemSketch is another tool used to draw chemical structures of organic chemistry, organometallics and polymers. It also computes molecular weight, density, molar refractivity and others (Gupta, 2023).

2.6 The effects of ICT on student engagement, understanding, and performance in Chemistry

2.6.1 High Academic Achievement

The previous research has established a strong positive correlation between the use of ICT and high academic achievement in the teaching of secondary school Chemistry. A vast body of knowledge says through the use of multimedia, including videos, animations, and graphics,

ICT can make difficult Chemistry topics more accessible and engaging, thus improving comprehension and interest in the subject. Better still, there is a wide range of very effective teaching methods like collaborative learning which is pupil-centred. ITC offers collaborative learning platforms where there are tools like online forums and collaborative software that enable students to work together on Chemistry projects and experiments, fostering teamwork and communication skills that are essential for academic success (Sotáková et al., 2020). A study in Canada concluded that the use of ICT in teaching Biochemistry as part of student engagement had a positive impact on students' understanding and hence high academic achievement. The findings of an experimental study in Turkey indicated an improvement and higher achievement of students in the ICT-based classroom than those in traditional classrooms. Chemistry students in Nigeria who were taught with the aid of ICT tools had higher academic achievement than when taught without any ICT tools (Owusu et al., 2023). In Ghana, high school students who had access to the internet had significant progress in their academic achievement than those who had no access most probably because they had access to an array of global resources which broadened their knowledge (Amponsah et al., 2022).

2.6.2 Improved understanding of learnt concepts

Research says ICT in chemistry education serves as a bridge between theoretical knowledge and practical application of concepts learnt, making learning more engaging, interactive, and effective (Ojha, 2016). By incorporating ICT tools, teachers are believed to create a learning environment that not only improves understanding but also inspires curiosity and a passion for the subject. Dori et al., (2013) opined that visualisations and models help pupils to grasp complex structures and reactions, which can lead to a deeper understanding of the subject matter in Chemistry. In well-resourced schools they use visualisations and molecular modelling software, which can help students to visualise complex molecules and chemical reactions, making abstract concepts more tangible and easier to understand. In Kenya, recent studies suggest that with ICT, the use of simulations can effectively mimic laboratory Chemistry experiments, which enables the students to conduct virtual experiments and observe chemical reactions in a controlled environment (Byusa et al., 2021). The research in Kenya concluded that hands-on experience leads to a better grasp of Chemistry principles and helps to develop higher-order thinking skills. (Gil-Flores et al., 2017) articulated that through the use of ICT, students can develop skills such as inquiry, graphing, and modelling, which are essential for a deep understanding of chemistry and scientific research in general. This current study wants to

establish the level of engagement, achievement and educational outcomes in Chemistry classes at Chemanhanzva due to the use of ICT.

2.6.3 Active participation in class

Contemporary research says collaborative online platforms, multimedia presentations, and virtual simulations in using ICT enable students to actively participate in their learning process. These technologies are believed to create an immersive and dynamic educational environment, encouraging students to explore concepts, solve problems, and apply theoretical knowledge to real-world scenarios (Kulshreshtha et al., 2023). In Zambia, ICT promotes active learning through collaborative learning and peer interaction (Kaunda et al., 2020). These collaborative learning methods fostered a sense of community among pupils, enabling students to learn from each other, share insights, and collectively construct knowledge. This research aimed to investigate if ICT tools produce active participation in a rural school setting using a case study approach rather than literature review that was employed in Zambia.

2.6.4 Pupils motivation to learn

Research articulated that ICT creates interest and curiosity which is the drive behind students' desire to learn. The use of technology engages students in more learning activities that can change the nature of the subject and stimulate the students to experiment, investigate and solve problems that bring depth to learning (Akinoso, 2022). The use of ICT forms the basis of interest and in turn, interest creates motivation. In Nigeria, research found that senior students had intrinsic motivation, and extrinsic motivation following the use of ICT in their learning of Chemistry (Bayuo et al., 2022). Porter et al. (2012) stated that learning motivation can guide personal learning goals, induce sustainable cognitive processes, and improve learning outcomes. In Indonesia, pupils reported that learning was interesting when their lecturer used attractive pictures, audio, and video to teach (Widyaningtyas & Wahidah, 2022). Although several studies have been conducted on ICT and motivation by many researchers, the area still needs more research because it is dynamic.

2.6.5 Increased knowledge retention and engagement

The impact of ICT integration on learning outcomes has been reported to have cognitive growth, skill development, and knowledge acquisition. Salameh Al-Rsa'i, (2013) opined that pupils become more engaged and demonstrate higher participation in learning as ICT is integrated into their learning. As such it is believed that learning becomes enjoyable, and as a result, students learn more effectively, resulting in increased knowledge retention. Empirical evidence shows that ICT-based teaching stimulates cognitive processes such as critical

thinking, problem-solving, and information processing. It encourages students to analyse complex concepts, evaluate information sources, and engage in higher-order thinking (Zuppo, 2012). In Dubai, e-learning and virtual environments were the ICT technologies which have a significant impact on knowledge retention (Alsarayreh, 2021). Based on the existing literature, the current study wanted to assess knowledge retention in Chemistry using ICT at Chamanhanzva where ICT resources are limited.

2.6.6 Inclusivity in learning

Some conventional schools of thought believe that ICT in the classroom has pathways that may be tailored to individual student needs, preferences, and learning styles which is inclusivity. Previous research points out that assistive technology can help students with special educational needs or language difficulties feel accepted and fulfilled in the classroom, while also promoting equal opportunities and enhancing the overall educational journey for all students (Méndez et al., 2023). Computers have software designed to help pupils in their learning process. There are programs like Computer Assisted Learning and others which help pupils. Furthermore, there are assistive devices including gadgets like screen readers, text-to-speech converters, and Braille keyboards that help students with visual impairments or learning difficulties to access educational content. These mostly work well with 'able-bodied' pupils and give them stamina in their studies. UNICEF (2015) put forward the idea that ICT can provide diverse options for taking in and processing information, making sense of ideas, and expressing learning for pupils with different styles of learning as studies in Colombia, Bangladesh and Mauritius revealed. There were communication platforms that allowed pupils with disabilities to attend school online using video conferencing and other communication tools.

Several research papers reviewed are in unison that people living with disabilities have been traditionally excluded from receiving an equitable education as the result of attitudinal, physical and infrastructural barriers within educational systems and throughout wider society (UNESCO, 2010). This research wanted to establish how available ICT infrastructure at Chamanhanzva addresses the concept of inclusivity in education.

2.7 Best practices for effective ICT integration in Chemistry Education

2.7.1 Interactive Virtual Laboratories

Access to laboratories and specialist Chemistry teaching materials allows students to view Chemistry in a more practical and stimulating manner. Various contemporary research papers have pointed to virtual labs as one of the best practices in the teaching and learning of

Chemistry in schools as an alternative to Chemistry labs. pHet is a virtual laboratory application accessed via the internet on certain websites (Rahmatullah et al., 2022). This application makes it easy for students to do chemistry experiments without going to a physical laboratory and in any place like their homes. Low-cost science kits enable teachers can also be procured to perform demonstrations (Gerick et al., 2017). They want to explore the possibility of Chamanhanzva having virtual labs for students and teachers.

2.7.2 Improving teacher status and digital skills

A plethora of research papers unanimously agree that ICT cannot replace the role of a teacher. Reviewed literature has highlighted that compromised teacher competence is a hindrance to ICT use in chemistry education, therefore, improving teacher status is deemed a potent issue in maintaining best practices. Due to Chemistry teachers' attrition, there is a need to improve the public perception of Chemistry teachers through salaries in the hope that this will attract more people to the profession (Gardner et al., 2018). Better still there is a need for professional development of Chemistry teachers for them to keep on track with the global trends in the field of chemistry education. In 2010, France formalised ICT skills training for all its teachers and training professionals via the creation of a certificate on the use of digital technologies and the Internet (OECD, 2016). Scholarships and bursaries can help to enrol teachers as in the case of South Africa where the South African Mathematics and Teacher Intern Programme (SAMSTIP) have made significant contributions to improving enrolment in BEd and PGCE courses in STEM and ICT disciplines (Khvilon & Patru, 2004). Continuous Professional Development through in-service training is also necessary to address the issue of under-qualified teachers.

2.7.3 Integration of local and indigenous knowledge systems

Another best practice which can help in the integration of ICT in Chemistry Education may be through integrating local indigenous knowledge systems in the Chemistry curriculum. The Heritage-based Philosophy of Education 5.0 in Zimbabwe also allow the integration of indigenous knowledge in teaching (Government of Zimbabwe, 2022). The iSPACES framework in Northern Tanzania is used as a case study to show how curricula may set traditional scientific work in the context of real problem-solving, fostering innovation and entrepreneurship. Previous studies have identified the integration of local and indigenous knowledge systems as a best practice in teaching Chemistry, this research wants to explore whether the same applies at Chamanhanzva secondary in Zimbabwe.

2.7.4 Equal access to ICT resources for pupils

An acute shortage of ICT resources was reported by many educational researchers. Best practices in the integration of ICT in chemistry education may entail ensuring equal access to ICT resources for pupils. Research has it that inadequate, inaccessible, unreliable, and insecure ICT tools pose challenges for teachers and students to use ICT effectively and efficiently (Msafiri et al., 2023). Pupils should use school computers for group work and to communicate with other students as the case in Turkey in 2009 where pupils shared school computers and internet access at least twice per week (OECD, 2016).

2.7.5 Aligning Chemistry Curriculum Objectives to ICT

There is a growing body of knowledge which says ICT tools should be aligned and integrated with curriculum objectives and content. Chemistry curriculum education planners should ensure that the use of ICT complements the chemistry curriculum and aids in achieving learning outcomes (Msafiri et al., 2023).

2.7.6 Creating ICT-based Chemistry assignments

Educational researchers believe that educators can design Chemistry assignments that require the use of ICT, such as creating models or simulations, to solve chemical problems. Students use computer simulations to model chemical reactions, allowing them to visualize and manipulate variables to see different outcomes. Students can conduct virtual lab experiments in a virtual laboratory, recording observations and drawing conclusions (Hogenbirk, 2020). Students can also use e-modules rather than textbooks (Rahmatullah et al., 2022).

2.8 Theoretical framework

This study will be guided by the Cognitive Development Theory by Jean Piaget and the Unified Theory of Acceptance and Use of Technology (UTACT) by Venkatesh, Morris, Davis, and Davis in 2003.

2.8.1 Cognitive Development Theory

This theory is mainly based on the work of Jean Paget, a Cognitive Psychologist. It provides a valuable framework for understanding how students learn and process information in the use of Information and Communication Technology (ICT) in teaching science subjects. Piaget's Cognitive Development Theory emphasises the importance of active learning, where students interact with their environment and construct knowledge (Fernandes et al., 2019). In this regard, cognitive theorists believe that ICT tools can create interactive and engaging science lessons that encourage students to explore, experiment, and discover concepts on their own. Basic tenets of the cognitive development theory articulate that students go through specific

stages of cognitive growth (Luhamya et al., 2017). ICT can therefore be tailored to suit these stages, providing appropriate challenges and support to the students. An example of this; younger students might benefit from ICT tools that offer concrete visualizations of scientific concepts, while older students might engage with simulations that require more abstract thinking.

The concept of the Zone of Proximal Development (ZPD) coined by Vygotsky complements Piaget's theory by suggesting that learning occurs well just beyond the student's current abilities through the concept of scaffolding. ICT can provide scaffolding with adaptive learning technologies that adjust the difficulty level of tasks as students' progress (Fu, 2013).

The Cognitive Development Theory also raises the concept of constructivism. This approach to learning suggests that learners construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences (Samphina Academy, 2022) . ICT can facilitate constructivist learning by providing virtual labs, simulations, and models that students can manipulate to build their understanding of scientific principles.

Better still, Cognitive development is also influenced by social interaction of pupils which is collaborative learning (Fernandes et al., 2019). ICT can support collaborative learning environments where students work together on projects, share data, and discuss their findings, thus enhancing their understanding through peer interaction.

The Cognitive Development Theory values immediate feedback and is considered crucial for learning and use of ICT. The basic premise is that ICT can provide instant feedback to students, allowing them to understand what they have mastered and what needs more attention (Fernandes et al., 2019). This aligns with the cognitive development theory's emphasis on the process of equilibration, where learners seek to balance new information with existing knowledge.

2.8.2 The Unified Theory of Acceptance and Use of Technology (UTACT)

This model was formulated by Venkatesh, Morris, Davis, and Davis in 2003 and consists of four main concepts; performance expectancy, effort expectancy, social influence, and facilitating conditions referred to as potential constructs to explain the perception of the user and acceptable behaviour (Moorthy et al., 2019). A critical predictor of technology use is behavioural intention (Venkatesh et al., 2003). The four major constructs were used in this study to examine how students perceive ICT use in the learning of Chemistry.

Moorthy et al (2019) explain the four domains as follows; Performance expectancy denotes the extent of advantages delivered to individuals in completing tasks through the adoption of a particular technology. Effort expectancy refers to the level of ease associated with an individual's adoption of technology. Social influence refers to the degree to which students recognise significant parties, such as peers, lecturers/ teachers, and family members. Facilitating conditions denote the students' insights into the availability of organisational resources and technical support affecting the adoption of an ICT learning system.

2.9 Chapter Summary

This chapter reviewed scholarly literature giving insight into the concept of the effectiveness of the use of ICT in secondary schools. A brief historical background of the use of ICT in education was given. The chapter explored the level of utilisation of ICT in schools. School policies regarding the use of ICT were briefly presented in this chapter. The importance of ICT challenges in implementing the use of ICT in schools was traversed in this chapter. The effects of ICT on student engagement, understanding and performance were explored as previous research portrayed. Chapter two also highlighted the best practices for the effective use of ICT in Chemistry education in secondary school settings. Theories which were propounded on the use of ICT in schools were presented. Knowledge gaps were established on concepts presented in this chapter which gave the green light to carrying out this study. Chapter three will explore the research methodology.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

Chapter three presents the research methodology chapter and the methodological underpinnings of this research on the effectiveness of using ICT in teaching Chemistry. This study adopted the relativistic constructivist approach based on the fact that there are multiple realities surrounding the concept under study. The other pertinent research design and aspects such as sampling, data collection, analysis, data quality and trustworthiness as well as ethical considerations are explored in this chapter.

3.2 Research Design

Tichapondwa (2013) defines research design as a plan or strategy which is developed to seek and discover answers to research questions. It also entails the selection of respondents, data gathering techniques and data analysis to be done. This study used a case study design.

3.2.1 Research Paradigm

The constructivist epistemological approach was applied to this study because participants' views, meaning and interpretation of experience are subjective, varied and multiple so the researcher could not narrow them into a few categories or ideas as Creswell & Creswell (2018) posited. A phenomenological approach was used in the study to capture the lived experiences of participants as opined by Creswell & Creswell (2018).

Moreover, the researcher used relativistic ontological assumptions to understand multiple truths and subjective experiences of participants. Relativist ontology is a set of beliefs that reality is a finite experience, as put forward by Levers (2013). It also says nothing exists outside people's thoughts and people experience their external worlds differently. The choice of relativist ontology therefore helped to get multiple interpretations of experience and multiple realities about the effectiveness of the use of ICT in Chemistry classes.

All of the above was encapsulated in the interpretivist paradigm. Levers (2013. p3) has it that the interpretivist paradigm primarily focuses on "recognizing and narrating the meaning of human experiences and actions." This paradigm helped much by obtaining interpretations from the study's participants' viewpoints and unobservable subjective states which could not be reduced to statistical data and therefore made use of the qualitative data. The paradigm is also guided by the beliefs of the researcher and how the world should be studied and understood. It takes into consideration that knowledge is cultural, temporal, historical and subjective (Levers, 2013).

3.2.2 Research Methodology

This study used a qualitative approach where concern was placed on the assessment of participants' views, attitudes and behaviour regarding the effectiveness of the use of ICT in the teaching and learning of Chemistry in great detail (Tichapondwa, 2013). The qualitative approach involves exploring and understanding the meaning individuals or groups ascribe to a social or human problem and data is collected in participants' settings (Creswell & Creswell, 2018). The results generated from in-depth interviews were be analysed and evaluated against already existing literature. Since the experiences of people are not standardised and differ from person to person, the qualitative approach was ideal as it is a broad approach to the study of social phenomena.

3.2.3 Research Strategy

A case study is an in-depth and qualitative study of a particular group which can also be referred to as a case (Tichapondwa, 2013). This design allowed the researcher to explore the phenomena under study to be examined in its real-life context as a single entity. In this research, the concept under study is the effectiveness of the use of ICT in Chemistry education and the context is Chamanhanzva secondary. The 'case' refers to Chamanhanzva Secondary School.

The main advantage of the case study was that, by working together with the qualitative approach and through the use of phenomenology and interpretivist philosophy, the researcher managed to probe survivors using in-depth interviews and being in the natural setting of the Chamanhanzva secondary. After that data was analysed on what the respondents said and also paying attention to the behavioural aspect like gestures, emotions and other issues of concern to the research.

3.3 Research Methods

3.3.1 Population and sampling

Population according to Best and Khan (1993. p13) refers to "…any group of individuals that have one or more characteristics in common that are of interest to the researcher". Shumayawonda (2011) adds that the group is the one in which the researcher is interested in gaining information, drawing conclusions and to which the results will be generalized. Chamanhanzva Secondary has about 200 pupils taking Chemistry in both form 3 and 4.

3.3.1.1 Sample Size

Borg and Gall (1989) define a sample as "a given number of subjects from a defined population which is representative of it". The study involved 20 participants. This enabled the researcher to obtain information from all age groups and gender in the Chemistry classes

3.3.1.2 Sampling procedure

This research used purposive sampling a type of non-probability sampling. Merriam (1988) described purposive sampling as based on the assumption that one wants to discover, understand and gain insight. The participants were chosen because of the defining characteristics like gender, age and class. The sample was well representative in terms of gender, age and social background.

Participants were chosen upon availability or convenience thus respondents were selected because of their convenient accessibility and proximity to the researcher on the day interviews were done. The purposive and convenience sampling were preferred for this research because they are relatively fast in terms of data gathering and less expensive in financial terms, also the potential respondents were readily available at the school. Moreover, due to the limited time available for the compilation of the research report, purposive sampling based on the availability and willingness of the participants was an ideal method.

3.3.2 Research Instruments

3.3.2.1 In-depth Interviews

In this research, an interview was used to collect research data from teachers. The researcher had a face-to-face interview with the participants. Tichapondwa (2013) defines an interview as a data collection method which involves the collection of data through direct contact between the researcher and the respondents so that the researcher obtains certain experiences which enhance an in-depth understanding of the concept under investigation. The interview guide had open-ended questions which were administered to respondents.

The advantages of using interviews for the study were that Face-to-face interaction through interviews had an outstanding advantage in that the researcher used probes which promoted verbatim recording of responses which in turn provided immediate feedback and gave room for clarification of questions, hence the researcher could immediately cross-checked data for authenticity. In addition, the researcher was able to immediately validate the data when sensing that the respondent was giving false information through non-verbal cues, including facial expressions and tone of voice. Interviews were more useful in obtaining detailed information about the personal feelings, perceptions and opinions of participants regarding the effectiveness of ICT in Chemistry education. They also allowed more detailed questions to be asked to the participants. The interview is expected to achieve a high response rate, thus all intended participants may be reached and their responses will be captured by the interviewer who is the researcher in this case. Respondents' own words will recorded for qualitative data analysis.

Ambiguities were clarified and incomplete answers were followed up. Precise wording was tailored to respondents and the precise meaning of questions was clarified. The interviewees were not influenced by the other participants. In terms of financing the interview is considered relatively less costly to administer.

Few backdrops may have been experienced in the process of interview administration. These include times when participants would act like they wanted to please the researcher hence raising the problem of truthfulness of the information provided. Also due to the translation from English language to the participants' native, there is a high likelihood of a challenge of interviewer dominance in narrating and trying to clarify the interview questions.

3.3.2.2 Focus Group Discussions

Tichapondwa (2013. p128) defines focus group discussion as "a small group of people who have a common interest or characteristic assembled by the researcher who uses the group and its interactions as a way to gain in-depth information about a particular topic". The focus group discussion was used to complement the interview where new and unexpected information emerged thereby adding value to the study (Creswell, 2006). The basic assumption for carrying out the FGD was that group interaction would be productive in widening responses stimulating details which are forgotten and allowing participants to open up (Tichapondwa, 2013). More so the fact that participants discussed among themselves helped to overcome the weakness of the interview where the researcher would dominate the discussion.

Two groups of 8 pupils each met in the school lab for one hour and thirty minutes at most. Arrangements were made before the discussion. The first group comprised form 3 pupils and the second group had form 4 pupils. Discussion notes were taken in notebooks and also consent was sought to record the discussions by audio means.

3.3.3 Data analysis methods

Research data was analysed using themes. During interviews, respondents' views were recorded in a notebook. When all respondents' views were captured, data was organized into themes and coded according to similarity. Themes were developed as respondents gave their views. Therefore after the interview process information was sorted into relevant categories by the researcher.

According to Mhlanga and Ncube (2003) case study data analysis is done at three levels which are:

- **Interpretation analysis** refers to the examination of data for constructs, themes, categories and patterns that help to explain the phenomenon under investigation. The researcher thematised the research data and put it into categories so that it would explain the concept of the effectiveness of ICT in the teaching and learning of Chemistry.

- **Structural analysis** examines the data for patterns in discourse and text with significant inference to the meaning of the patterns. For this study inferences were made to the data grouped in categories and applying respondents' views.

- **Reflective analysis** involves making value judgements on the phenomenon. The case study report presentation becomes a reconstruction of the respondents' reality through a richly descriptive narrative of their values, perceptions, experiences and feelings. The researcher made judgements on views given by the respondents as was in the categories in which data was put.

Research data research was analysed as follows:

The researcher manually analysed the research data. The first step was data cleaning. This step is meant to get rid of duplication of data and correcting errors. The data was coded or grouped into themes from bio-data to actual interview and FGD questions where they were analysed descriptively and inferences were made. This helped to identify similarities and differences between data and also grouping data into themes helped to sort research information according to homogeneity, in this research data was analysed according to research questions from which they were drawn. The researcher also used content analysis for coding and classifying research data. This helped to make sense of the data collected and to highlight the important findings. The researcher will also analyse data from the research by re-contextualising, referring the research findings to the reviewed literature in chapter 2 of this report.

3.4 Data quality and trustworthiness

The researcher ensured data quality and trustworthiness by employing various means. In terms of data quality, the research was guided by setting up research variables, defining the study population as indicated in this chapter and employing theoretical perspectives and work of other specialists in the area of the use of ICT in teaching and learning.

Regarding credibility the sampling procedures used, thus purposive sampling in the juxtaposition of choosing participants who were present on the day of the interview and FGD was a flagship and gold standard for this study. Moreover, two data collection methods were

used namely; interview and Focus Group Discussion where each of the two would compensate for the weaknesses of each other.

For trustworthiness to be certain in this study, the researcher interviewed actual pupils and teachers at Chamanhanzva, the study did not rely on key informant interviews only because their views would be biased and lacked the lived experiences of the teachers and pupils.

Lastly, the aspect of transferability was accounted for by providing actual details of the study context about the place of study and the effectiveness of the use of ICT in Chemistry Education. Again the steps of research were done through the examination of raw data and transcribing it from the notes taken from the interview and FGD. The raw notes were made available for re-analysis of the concepts by interested experts in the field of educational research and also peers in the same field of study.

3.5 Ethical considerations

This study observed ethics used in the practice of educational research as follows:

3.5.1 Permission to carry out the study

The researcher obtained a clearance letter from the District Education office before carrying out the study. The gatekeeper's permission was then obtained from the school Head before the administration of interviews and FGD to the participants.

3.5.2 Informed consent

The researcher educated the participants to ensure that they knew the objective and purpose of the research and the potential benefits before they decided to participate in the study. Those who volunteered to participate were given individual consent forms to complete and affirm their participation in the research. Legal minors' consent was done by the school administrators. Participants were also informed that it was their right to withdraw at any stage from participating in the study. An explanation of the intention of the research and how the information is going to be used was given to the participants.

3.5.3 Confidentiality

Participants were assured that the data which was collected was going to be stored securely under lock and key, for notebooks and notes and also typed material would be secured with passwords to avoid unauthorized access by other persons and to ensure the protection of their privacy. Also, they were informed that their views were not meant to be used for public consumption but for academic purposes only.

3.5.4 Anonymity and privacy

The participants were also assured that in the final research report their views were not going to be identified by their actual names but pseudo names were going to be used.

3.5.5 Respect for persons

This research also upheld the ethic of respect for persons by promising to ensure that the research would benefit the education sector. Again there was assurance to put effort into sharing the study results with the Ministry of Primary and Secondary Education.

3.6 Chapter Summary

This chapter presented the research design and the research method to be used for this study. The chapter also presented a case study design which was applied in carrying out this research. Other methodological issues discussed in this chapter are, the study population, sample size, sampling procedure, interview and FGD as research tools, the procedure which was to collect research data, research data analysis, data quality and trustworthiness and ethical considerations which were observed in carrying out the research. Chapter four will focus on data presentation.

CHAPTER 4
DATA PRESENTATION, ANALYSIS AND DISCUSSION/ INTERPRETATION

4.1 Introduction

This study sought to explore the effectiveness of ICT in the teaching and learning of ordinary level Chemistry at Chamanhanzva High School in Chivi District. This chapter presented data gathered through interviews and focus group discussions with the research participants. The research findings are presented qualitatively and quantitatively to elaborate some data. Research data was also analysed and interpreted in this chapter. The chapter presented the participants' views from in-depth interviews and Focus Group Discussions which are coded in line with the research questions and items on the interview guide and FGD schedule as guidelines. As outlined in the previous chapter, the researcher used mixed coding in the data presentation, thus themes or headings used were derived from the research objectives and the reviewed literature as well as themes arising from the research participants' views.

Table 4.1 Participants demographic data

Variable	Number (*n*)	Percentage (%)	ICT
Male Teachers	2	10	Yes
Female Teachers	2	10	Moderate
Form 3: Male	4	20	Learning
Form 3: Female	5	25	Learning
Form 4: Male	4	20	Moderate
Form 4: Female	3	15	Moderate
TOTAL	**20**	**100**	

This research had 20 participants. There were 2 male teachers and 2 female teachers. There were 4 male form 3 students and 5 female students. Form four pupils were 4 males and 3 females. The sample size was 20 as given in Chapter 3 and therefore the research went on as planned as it managed to get a 100% response rate for the Interview and FGD participants. The sample was balanced in terms of gender for pupils and teachers as it contained both male and female respondents. Ten per cent of the study sample reported that they were proficient with ICT whilst 45% said they were moderate and the other 45% said they were still learning. ICT proficiency of the participants with only 10% reporting being proficient shows that there was minimum use of ICT in the teaching and learning of Chemistry at Chamanhanzva.

4.2 The current level of ICT utilization in Chemistry teaching at Chamanhanzva High School.

4.2.1 Types of ICT tools suitable for pupils to understand Ordinary Level Chemistry

The interviewed respondents identified four types of ICT tools they deemed suitable for teaching and learning for pupils to understand Chemistry. ICT gadgets identified include computers, smartphones, tablets and projectors as ICT tools suitable for understanding Ordinary level Chemistry at Chamanhanzva High School. Numbers show that smartphones are considered the most ICT tools for teaching and learning chemistry. Respondents said they used them for research and teachers would send notes and related stuff to pupils using smartphones.

Table 4.2: ICT tools suitable for teaching and learning Chemistry

ICT tools	Computers	Smartphones	Tablets	Projectors
No. of people (n)	4	11	3	2
Percentage (%)	20	55	15	10

Table 4.1 above shows that 55% of the participants in said smartphones are good for pupils to use and understand Chemistry. The other participants preferred computers (20%), tablets (15) and projectors (10%). The following extracts illustrate something about the respondents' views on the ICTs suitable for understanding chemistry:

> *" …projectors are better because they allow every pupil to have access to concepts being taught rather than other means like smartphones and laptops which most of our pupils from rural schools do not afford. Almost every science teacher has a computer to use with the projector but the school has only one projector which is largely used by the ICT and Maths Department and therefore securing it from the department is very difficult. We end up using smartphones to send helpful Chemistry stuff to pupils so that they have access at home or school though the school does not allow pupils to bring phones to school*". [Male Interview Respondent]

> *"Smartphones can do virtually everything; research, learning online, storage of chemistry information, communication, typing and many other functions. Most parents afford to buy a smartphone for their child to use for school purposes while others can share their devices with their children who use them for research. Smartphones are better than any other ICTs in chemistry…" [FGD participant].*

The research participants therefore revealed that smartphones are the most accessible ICT tool for understanding chemistry at the ordinary level of education. They highlighted that Chemistry teachers can use smartphones for sending work to pupils and also pupils research and communicate with their teachers using digital platforms, especially WhatsApp. Smartphones were the most effective ICT tool for teaching Chemistry as respondents said pupils received work from teachers using smartphones. Teacher respondents said they accessed information from the internet using their laptops and sent it to pupils using smartphones. Pupils also said they would use their smartphones or their parents' and/ or guardians' phones.

4.2.2 Integration of ICT tools in Chemistry lessons

Interview respondents said ICT tools were rarely used in Chemistry lessons. Teachers who were interviewed said they only had a whiteboard which they used in place of a chalk-blackboard as a way of avoiding the use of chalk in the laboratory. One female teacher said:

> *"I use my laptop and smartphone during the lessons as teaching aids. Unfortunately, pupils cannot see some diagrams and graphic information which they are supposed to know. As such for some critical stuff, I call the pupils in groups so that they view from my laptop from a closer distance or share with some who have smartphones. If we could have a computer and projector specifically for science classes it would be better. It is rather unfortunate that the school does not allow pupils to bring phones to school so we use our devices during lessons but pupils access the information on their phones at home after school. In this age of technology, interactive whiteboards would be excellent to use in Chemistry lessons.*

These findings show the school has limited ICT tools for use in Chemistry lessons and teachers resort to personal gadgets which they use to achieve lesson objectives. A pupil said:

> *"I enjoy online discussions with fellow pupils and the teacher because we receive videos and electronic books which are not readily available at school and I do not dream of buying them in bookshops because I do not afford to buy one. For my studies, I use the smartphone to research and watch various videos on Chemistry experiments".* [Student FGD participant]

Respondents unanimously lamented the limited availability of school-provided ICT tools which resulted in them using personal ICT gadgets. In this case, pupils co-jointly use their ICT tools for school Chemistry lessons and extra work which is done outside the school time-tabled lessons. These current research findings are in tandem with Petry & Moss's (2019) conclusion

that a wide range of ICT gadgets was found in schools but there was no clarity on the ownership of the gadgets in their research. Findings from this research reveal that most of the ICT tools in schools were personal gadgets of the teachers, laptops and smartphones and pupils also own some smartphones which goes together with Molotsi's (2022) view in the related literature review that schools had few gadgets but teachers were reluctant to use them. There is a discrepancy with the current research where respondents revealed that they were willing to use ICT tools but the resources were not available in the school and they used their gadgets sparingly. Furthermore, the idea of bringing own ICT devices goes together with findings in European countries as presented by the European Commission (2019) that some nations have a policy of Bring Your Own Device (BYOD) as revealed in the reviewed literature. At the school where the research was conducted bringing own devices was not a policy but probably school's lack of financial resources to procure the ICT gadgets for use in the Chemistry lessons.

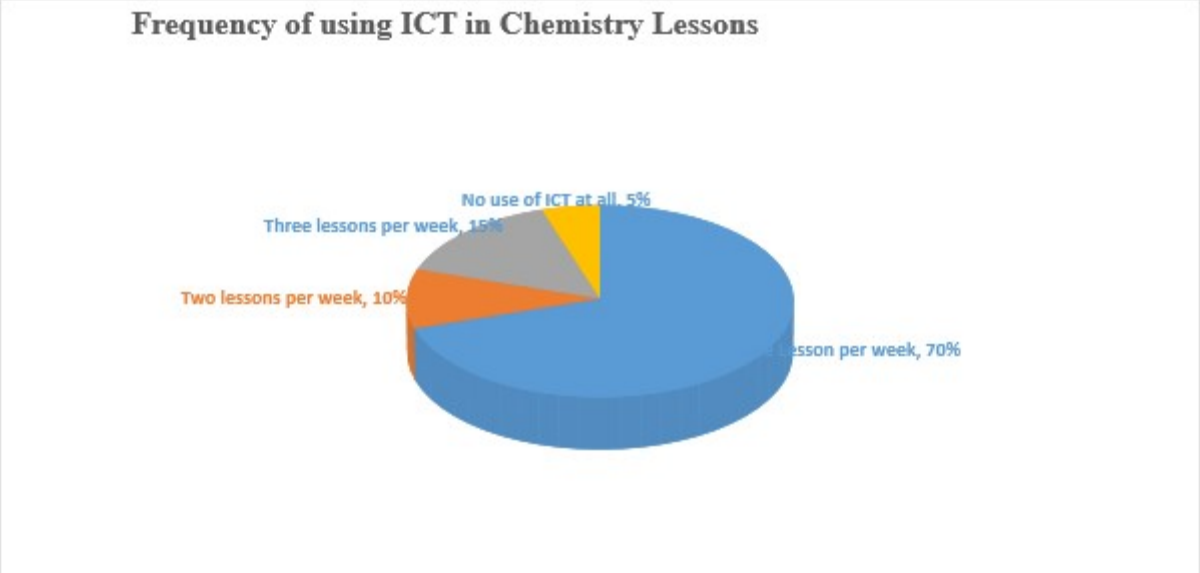

Figure 4.1: Frequency of using ICT tools in Chemistry lessons (*n*=20)

In response to Question 1 on Interview for teachers and FGD for pupils Figure 4.1 above shows combined figures for both teachers and pupils that 70% (14 participants) of the participants said ICT tools are used in Chemistry lessons once per week. Fifteen per cent (3 participants) of the participants said ICT tools were used thrice per week. Ten per cent (2 people) of the respondents said ICT tools were used twice per week. Lastly, 5% said no ICT tools were used in Chemistry lessons. Previous research on the frequency of the use of ICT in teaching was hampered by the lack of adequate pedagogical skills of teachers to deliver lessons using ICT, thus lack of teacher competency as opined by Bingimlas (2009) in the reviewed literature. Another prior research by Belay (2020) cited pupils as the reason that the use of ICT was not

successful because pupils had not yet embraced ICT education in schools. In the case of Chamanhanzva using ICT tools in one lesson per week as the majority of the respondents said could be a signal of the lack of ICT resources at school as articulated by a respondent:

> *"…our school does not have any computer for the science department and where we bring our laptops we have limited access to the single projector which is owned by the Computers Department…"* [Interview respondent 1].

The respondent's view above shows that using ICT tools once per week and not using ICT tools at all would imply that the resources are unavailable. This finding is divergent from the view raised in the previous research as in the reviewed literature (Bingmals, 2009) that some teachers lack the pedagogical skills to deliver lessons using ICT tools. The lack of teacher competency as previous literature said was not found in this research, rather a respondent said:

> *"Teachers were trained to use ICT at tertiary institutions and are therefore competent enough to use ICT gadgets for lesson delivery…".* [Farai]

Therefore the current research findings show that the frequency of using ICT tools in teaching Chemistry lessons is less frequent and mostly hampered by either or both unavailability or limited supply of ICT gadgets in the schools for use by students and teachers.

4.2.3 Ways in which ICT changed the approach to teaching ordinary level Chemistry

The current research participants said using ICT has greatly positively improved the various aspects of teaching and learning Chemistry. The positive impact of using ICT as reported by respondents is that it has revolutionised teaching and learning by improving syllabus coverage through administering more work in a short space of time.

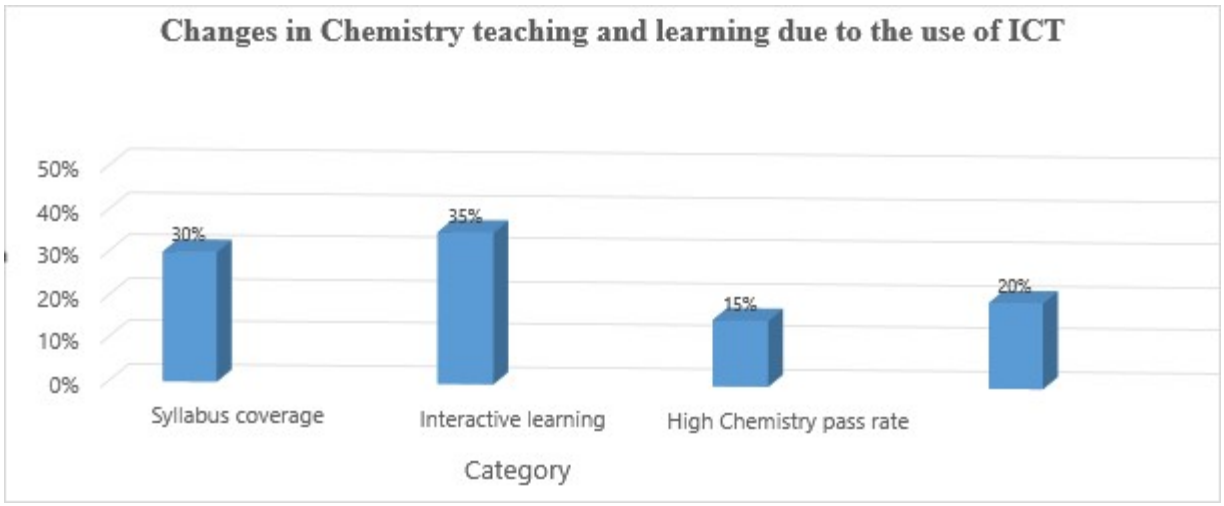

Figure 4.2 Changes in Chemistry teaching and learning due to the use of ICT (*n=20)*

In Figure 4.2 above, FGD and interview participants showed that the use of ICT has changed their teaching and learning of Chemistry in various ways including covering all syllabus concepts within the specified time of the ordinary level Chemistry Syllabus as 30% (6 participants) of the interviewed people said. A total of 35% (7 respondents) said ICT tools are good for interactive learning. Another 15% (3 respondents) said the use of ICT use in teaching Chemistry resulted in an improved pass rate of Chemistry. Again 20% (4 respondents) of the participants reported that ICT gave them access to advanced learning materials.

The views from the respondents show that the use of ICT has transformed the teaching of Chemistry at Ordinary level making it more learner-centred through access to advanced learning resources and interactive learning. Better still the respondents' views may imply that ICT empowers pupils with critical thinking skills as they use the tools for research and also generating new skills. This resonates well with Mangwaya et al (2019) view that ICT has improved the quality of teaching and learning for the benefit of pupils which may be through a high pass rate in summative exams as other respondents reported.

4.3 The effects of ICT on student engagement, understanding, and performance in Chemistry.

4.3.1 Pupils' experiences

How has the use of ICT affected pupils' engagement in Chemistry classes?

Various views were raised by students which show the positive effect of the use of ICT in chemistry theory lessons and practical lessons. The majority of the pupils in FGD said ICT motivated them and promoted collaborative and peer working among the Chemistry class students. A student said:

> *"the animations from demonstration videos make the lessons with our teacher, more interesting than using textbooks and we share ideas on tasks given by the teacher. Besides electronic documents and video clips from the teacher, we are given research areas to research concepts from the internet using smartphones which makes the learning experience fascinating".*

The findings from this research show that ICT in Chemistry lessons caught the attention of pupils and created curiosity, interest and motivation to learn mainly due to the use of simulations. This is in line with the reviewed literature which revealed that ICT increases pupils' motivation as articulated by Bingimlas (2009) and Bayuo et al (2022). maybe with the use of images from computer-aided visual aids in a 2D or 3D format which Msafiri (2023)

highlighted in the reviewed literature. The idea of meeting individual differences in using ICT was not found in this research, probably because the ICT tools used in the school do not meet the individual needs of pupils as the pupils reported not using online quizzes and modules. The form of ICT tools used at the school, thus smartphones, computers and others have no software to address the individual needs of pupils with special needs as part of inclusive education which Méndez et al (2023) advocated for. The findings of this research did not show any use of sophisticated software and assistive devices in the teaching and learning of Chemistry. The reason would be that there were no pupils with special needs, therefore it was not on the priority list, hence there was no need for devices which would promote inclusivity of the pupils living with disabilities.

4.3.1.1 Interaction with peers using ICT tools

Respondents reported that they usually have online discussions, especially the form four pupils who are going to write summative exams at the end of the year. They said they have peer groups for discussion purposes whereby they have forums to ask peers questions and get answers. Moreover, some respondents reported sharing resources like electronic textbooks for chemistry downloaded from some websites which offer free science resources. A Form 4 respondent said:

> *"We research all our Chemistry work on the internet at home. We have benefitted most from research on CALA and we share our resources and everything we get from our study group members. There are some websites like Labster which allow us to have virtual lab simulations and we discuss the results of virtual experiments with other peers from the rest of the world".*

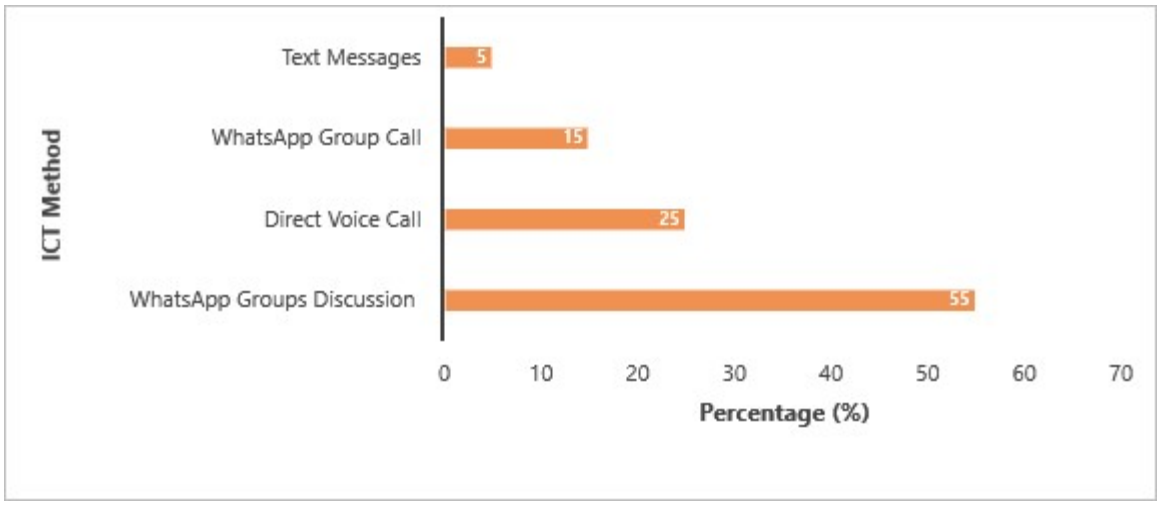

Figure 4.3 ICT tool of choice for pupils (*n=20)*

In Figure 4.3 above, research findings show that WhatsApp is the prevalent form of medium for sharing Chemistry resources and information as combined statistics of WhatsApp Group calls and Group discussions have 70% (14 respondents) altogether. The reasons cited include that data is cheaper compared to other means of communication. This was followed by direct voice calls where 25% (5 respondents) reported phoning each other for assistance in chemistry work at home and 5% (1 respondent) used text messages to contact others from a guardian's phone. All these means are centred on smartphones. This shows that pupils mostly use smartphones as ICT tools of choice.

4.4 The role of ICT in the motivation and interest of pupils in continuing to study Chemistry

This study's respondents unanimously declared that the use of ICT helps them to keep and sustain an interest in the field of Chemistry. The respondents reported various means that would sustain pupils' interest including having access to cheap Chemistry resources found online, encouraging collaborative working among students, replacement of bulky books by visiting physical libraries and making Chemistry interesting and understandable.

Some pupils reported benefitting through enhanced understanding when teachers used aids for the visualisation of complex structures of molecules through ICT devices such as smartphones and computers like animations and simulations. Furthermore, respondents highlighted that ICT enlightens them with vast resources from online libraries and virtual labs for virtual experiments. Themes extracted from the FGD are presented in the table below:

Table 4.3 The motivational role of ICT in the continuous study of Chemistry (*n=16)*

Motivational role of ICT	Cost-effective Chemistry resources	ICT promotes collaboration between peers and other tutors after school.	ICT replaces bulky books and material	ICT Makes Chemistry more interesting and understandable
Number (*n)*	4	5	3	4
Percentage (%)	28	32	16	24

From Table 4.3 above it can be observed that 28% of respondents reported that ICT is the chief route to cheap (cost-effective) resources for chemistry, which may be through free online resources. It was noted that 32% of respondents said ICT tools promote collaboration between peers and other tutors after school to further their understanding of learnt concepts. The other 16% of respondents reported ICT tools replaced bulky Chemistry books and they had their

digital Chemistry resources stored in ICT devices and they could access them without struggle. The last 24% said ICT made Chemistry lessons more interesting and understandable. These findings resonate well with Salameh Al-Rsa'i, (2013) opinion that the use of ICT raises the pupils' motivation to learn. Zuppo (2012) concurred with this opinion saying ICT results in higher-order thinking whereby students analyse complex Chemistry processes as part of motivation triggered by ICT tools used for teaching and learning.

4.5 Teachers' views on the effects of ICT on student engagement, understanding, and performance in Chemistry.

4.5.1 A specific instance where an ICT tool made a Chemistry lesson more engaging for the teacher.

One of the respondents explained that they had a lesson using a projector. She reported that their experience in atoms, protons and neutrons was excellent as the projector provided them with 3D animations and simulations that brought the concept to reality and increased the participation of pupils in class discussions both theory and practical lessons. The projector acted as a media and medium of realia. According to the educator, the lesson was highly engaging:

> *"…the lesson was highly motivating as it caught the attention of pupils. Even after the lesson, pupils managed to relate concepts, and retain what they learnt and self-directed learning, showing content mastery. Better still, pupils' attitudes towards Chemistry improved…"* [Mr Rufiyatu].

The teachers' perceptions as key findings from this research on the use of ICT in teaching Chemistry imply that pupils have a better retention capacity where they can retain learnt Chemistry concepts as the lessons are more practical than just theory. Similarly, Ojha (2016) noted that ICT tools have a very high potential for the retention of concepts making learning more engaging, interactive, and effective. Alsarayreh (2021) concurs as seen in the review of related literature that ICT technologies have a significant impact on knowledge retention. There are a few discrepancies found in this research as compared with previous research; the issue of knowledge creation by pupils resulting from the use of ICT as coined by Kulshreshtha et al., (2023), there were no reports of pupils creating new knowledge, maybe because there were no follow-ups on the pupils after completing their ordinary level studies. Another outstanding discrepancy is that educators never mentioned high academic achievement or improved pass rates in Ordinary level Chemistry as directly linked to the use of ICT tools whereas Sotáková et al (2020) postulated that ICT results in high academic achievement. Again, the idea of

inclusivity in education using ICT as raised by Méndez et al (2023) has not been found in this research, otherwise, the use of ICT especially from home is enough discrimination for the pupils hence militating against inclusive education.

4.5.2 Ways in which ICT tools helped teachers to deliver complex ordinary level Chemistry concepts better in their lessons

The four teachers interviewed reported that ICT tools helped them to deliver their lessons well. Two of the interviewed teachers said ICT tools helped them to make chemistry concepts more accessible to learners. One of the teacher respondents said, that in the face of extreme challenges rocking the schools where chemicals and apparatus are not readily available when needed, ICT would help pupils through virtual labs as an alternative to practical lessons, an idea precluded in the reviewed literature as put forward by Rahmatullah et al (2022). Another teacher said ICT helped them to deliver complex lessons using a project-based approach. An interviewed teacher, concerning making concepts more accessible to pupils said:

> *"Traditionally, we used to have physical libraries and referred pupils to the library for some syllabus recommended textbooks, now we have online universities and colleges repositories to which everyone has free access. It is easy to teach pupils who have grasped the concept before they come for the lesson as they have better participation and they are better to engage".* [Ms Eliot].

Mr. Mbofana said

> *"I prepare lesson notes in advance using PowerPoint and during lesson time I use the projector to explain the complex concepts thereby avoiding writing notes on the board. Therefore, most of my instructional time goes towards engaging pupils and they take notes from the power point also I share soft copies of notes with them so that they can use the notes at home for studies. In reality, I save instructional time and emphasise complex tasks which can help to explore all methods that help to achieve lesson objectives so that pupils successfully grasp the concepts taught. Besides saving time, we also encourage pupils to visit different websites like YouTube, for experiments since they have practical lessons and a practical examination at the end of the ordinary level."*

These participants' views corroborate previous research that the use of ICT simplifies complex concepts by using attractive pictures, audio, and video to teach and hence motivating pupils to learn as was echoed by Widyaningtyas & Wahidah (2022) that ICT is a hook that captures.

4.5.3 Changes in your pupils' academic performance in Chemistry since the integration of ICT in the teaching process

4.5.3.1 Positive changes

4.5.3.1.1 Higher academic achievement and retention

The study respondents reported that the use of ICT as technology-based instruction in teaching ordinary level Chemistry produced higher academic achievement and retention in learnt Chemistry concepts than when using traditional methods. Mr Chihowa said:

> *"I have observed that current technologies like the use of attractive images, audio, and videos in the Chemistry lessons enable pupils to pay attention and in that mode, they grasp concepts faster than using lecture method and group work alone. In terms of participation, even the passive pupils are motivated to participate, from my experience in using ICT ".*

4.5.3.1.2 Change in attitude towards science subjects

Some respondents reported that the use of digital technologies through ICT in Chemistry classes has changed the attitudes of pupils towards the subject. An interviewee said:

> *"It is not teaching chemistry, pupils gain some digital skills through the use and sharing of learning digital materials. The idea gives them a positive attitude towards the subject leading to interest, better performance and improving the academic outcomes."*

The findings imply that there may be a strong positive correlation between positive attitude and interest and better academic performance in chemistry through the use of ICT as the use of ICT has resulted in enhanced learning outcomes.

4.5.3.1.3 Improved lesson attendance

The research participants also identified improved lesson attendance as another issue of importance in the use of ICT in teaching chemistry. The participant who raised this idea said:

> *"When pupils know that we use ICT tools in our lessons, they come earlier to the Chemistry lab. Pupils attend lessons consistently both physically at school and in online classes where they just want to experience the online discussions. They also attend in large numbers because they like the experience and use of digital tools".*

This idea of improved lesson attendance is new as it was not mentioned in the reviewed literature. It may be closely linked to the concept of motivation. Students attend chemistry lessons possibly due to extrinsic motivation which is triggered by ICTs in the form of videos, audio and others.

4.5.3.1.4 Creativity

Some interviewed participants said ICT use in the teaching of chemistry led to creativity in the students. Through the exploration of various multimedia tools, ICT has led to creativity in some pupils.

> *"We have some pupils who have designed models which we now use in teaching. Some of them even excel in science exhibitions that are done annually. They learn from our lessons but some even research on their own which helps to have live discussions in class. The students' creativity can be seen in class when some can compare experiment results data using graphs, tables e.t.c or from outside chemistry classes and even at home."*

4.5.3.1.5 Learners' autonomy in learning due to the use of ICT gadgets

Figure 4.4 below shows that pupils develop a sense of autonomy by the mere fact of using ICT in chemistry education. A total of 54% (11 respondents) reported that some pupils study optional topics and excellently answer questions from those topics that were never taught in class. Also, 40% (8 respondents) said pupils read ahead on some topics without teacher guidance as a sign of learner autonomy and creativity steered by the use of ICT. The last 6% (1 respondent) said pupils who grasped the concepts well using ICT practised peer teaching. These findings characterise learner autonomy promoted by ICT use in teaching and learning.

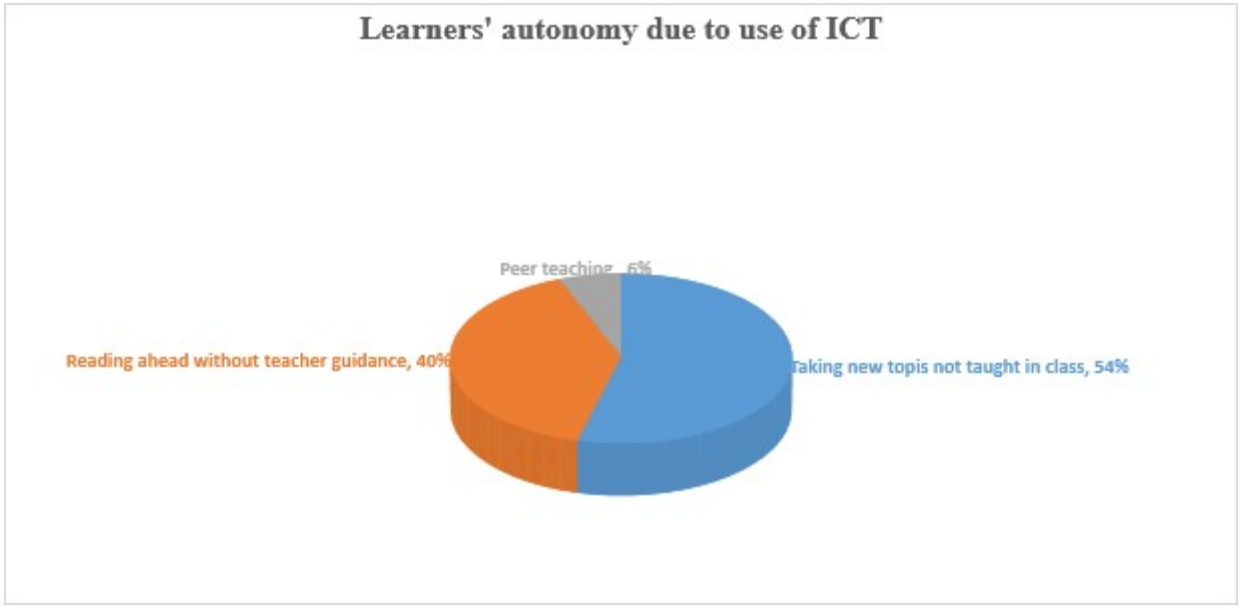

Figure 4.4 Learners' autonomy due to the use of ICT (*n=20)*

4.5.3.1.6 Pupil-Centred learning

Other participants pointed to a pupil-centred learning environment which enhances pupils' understanding of chemistry concepts through gaining ownership of their learning. A teacher highlighted that some pupils have become more knowledge creators through creativity than passive learning from the teachers and books as the sole sources of knowledge. Some ICT tools like tablets and phones allow social media connectivity leading to interactive participation through online platforms that include WhatsApp which was rated as the most used platform. The results regarding the learner-centred approach corroborate the findings from previous research as indicated by Ncube (2020). The only discrepancy is that of teachers tailoring the teaching and learning to suit individual needs. At Chamanhanzva there is no such teacher-organised individualised learning for pupils probably because they are using platforms and tools that do not support individual needs, or they do not afford software that supports individualised learning to meet the individual needs of pupils. Rather there is a new format of individualised learning where pupils take the lead to access the information at their own pace during their own spare time so that they address their own special needs and interests.

4.5.3.2 Negative changes

4.5.3.2.1 Distraction from school-work

The research participants also reported that the use of ICT in the teaching and learning of Chemistry has a high potential of pupils getting a lot of distractions. A teacher respondent said:

> *"There are cases where pupils get carried away with social media platforms content, online games, porn and dating sites, thus doing more harm than good to the students…".*

This shows that in as much as ICT can be useful in the learning of pupils, there is a need to monitor pupils' devices like phones, computers and other gadgets.

4.5.3.2.2 Plagiarism and cheating

Other respondents have lamented high levels of plagiarism which may be mistaken for creativity. Mr Mutanda said:

> *"Pupils who excel much in using ICT, especially the internet, in their research work can plagiarise other people's work and appear as creative students. In cases where the teacher may not detect plagiarism, it leads to pupils going as far as cheating when writing tests. In this regard the students may not develop creativity, ICT may create dependency which leads to plagiarism and cheating".*

The results, in this case, show that the use of the internet may lead to academic offences such as plagiarism and cheating. Therefore there is a high potential for killing creativity which in turn can lead to cheating in the assessment of their work.

4.5.3.2.3 Social stigma and discrimination among students

The respondents reported some social problems within the school system that may be promoted by the use of ICT gadgets, especially smartphones. Sources of discrimination that were identified include the non-availability of phones or ICT gadgets to some students, 'poor' quality or brand of devices used by a pupil, non-availability of data for the pupil, and gadgets owned by parent or guardian, not the pupil.

Table 4.4 Disparities created by unequal access to ICT gadgets

Category of stigma or discrimination	Frequency (n)	Percentage (%)
Non-availability of phone to the student	10	50
'Poor' quality of device used by pupil	6	30
Non-availability of data for the pupil	3	15
Owned by parent or guardian, not the pupil	1	5
TOTAL	**20**	**100**

Table 4.4 above shows that unequal access to ICT gadgets in the school Chemistry class can be a rich source of discrimination for the pupils which may negatively impact the pupils' learning. This implies that ICT gadgets have the potential to create inequality through the availability of inferior brands of phones or gadgets. Those without gadgets may bear the brunt of stigma and discrimination from those who have the gadgets. Some pupils who equally suffer the same fate as those without a gadget are those who have limited access to digital devices because they are owned by their parents. Some are discriminated against based on the notion that they have a gadget but they don't afford data or airtime to connect with other friends, hence affecting pupils' learning experience and engagement.

4.6 Best practices that can be implemented for integrating ICT in ordinary-level Chemistry

4.6.1 Manpower development/ In-service training of serving teachers

A recurrent view raised by respondents was the in-service training of the serving teachers. Teachers proposed the training of teachers for digital literacy and the use of ICT for subject-specific purposes. A respondent said:

"We trained teaching before the use of computers and other ICT gadgets, we need training for these new technologies. Sometimes we fail to use them because we are not proficient with the stuff, and this may lead to problems like being cheated by pupils especially when they can use information from the internet which we may not be able to verify".

This opinion by the teacher shows that some teachers may lack the skills to work with ICTs thus making it difficult to fully integrate ICT into chemistry classes. Also, it may be difficult to encourage the pupils to use ICT since the teachers may resort to the use of physical books, physical labs and physical experiments. Therefore in cases where physical materials are unavailable at schools, it may be a hindrance to the learning of Chemistry and both pupils and the teacher may lack the ICT skills needed for those who are likely to take Chemistry studies later at the tertiary level.

4.6.2 Forming Chemistry Teachers Association

Teachers echoed the sentiments that a Chemistry teachers association is necessary for the promotion of the use of ICT by teachers. They considered it as a route for peer sharing of ideas that can enhance the teaching of Chemistry. An interviewee reported that:

"An association that encompasses all chemistry teachers from all schools in Zimbabwe can unite us and help share ICT issues which also encourage us to keep abreast with the digital world in a global and 'glocal' world as we can share teaching resources and latest research, trends, and advancements in the field of Chemistry".

The extract shows that Chemistry teachers can collaborate which also promotes the use and sharing of ICT information, mentoring each other to adapt to new teaching technologies or addressing student needs.

4.6.3 Supply and maintenance of ICT materials

Respondents said there is a need for school's responsible authorities to supply ICT gadgets to schools so that they can be used for teaching and learning and both teachers and pupils familiarise themselves with them. Moreover, the supplied gadgets need service as they experience tear and wear since they are used by many pupils at school. As such no gaps are created in the process. Since all students will use ICT gadgets.

4.7 Barriers to effective ICT integration in Chemistry learning

4.7.1 Students' characteristics

FGD participants reported several barriers to the integration of ICT in learning chemistry. The major barrier reported is the student's lack of proficiency in the use of ICTs. The major impediment to students' lack of proficiency in ICT was identified as low socio-economic status, thus hampering their access to ICT gadgets such as smartphones and computers for use at home and school. Also, some pupils reported that at home their parents had no ICT gadgets and some had siblings who have smartphones but were not ready to part with them. With this background, some had no motivation to use them at school as they were not also readily available. On the other hand, older students in Form 4 said the fact that they had no ICT gadgets at home was the motivation for them to use the ICTs if they ever get the chance.

4.7.2 Teacher characteristics

There were also teacher characteristics impeding the use of ICTs in Chemistry learning. All female teachers reported that they were moderate in using ICT for teaching and learning. They said they relied on help from fellow teachers and pupils as well. Therefore, it was farfetched for them to administer meaningful instruction using ICT. Instead, the teachers said they had prepared *"...comprehensive notes handouts..."* for Form 3 and Form 4 to cover up for ICT.

4.7.3 School barriers

Institutional barriers were also noted. These include the lack of ICT gadgets. An FGD participant said:

> *"Our school has few functional laptops in the computer lab and they are mostly used for computer lessons, not for everyone. How can we learn then in this situation?" We are also not allowed to bring phones to school though teachers want to share some [digital] documents with us.*

Teachers added to this institutional challenge by saying:

> *"The school has a harsh policy on the use of phones in the school. Even if the new Guidance and Counselling movement allows students to use phones in the school, our school reserves the right to allow them, the students are not allowed to use phones on the school premises. They cite disciplinary issues and sharing of materials not related to learning and even disturbance to the learning process when students may be busy with their phones for content not related to school. Worse still, teachers are not allowed to answer phone calls during lessons under the pretext of disturbing the flow of teaching*

and learning. The internet is highly restricted as it is programmed to filter what we surf so that people focus on material that is deemed to be for teaching".

The students, teachers and school characteristics as barriers to the integration of ICT in the teaching of ordinary level chemistry support the previous research findings as outlined in the literature review. Therefore, there is a huge drawback in promoting the use of ICT and therefore teachers use the traditional methods of teaching Chemistry using textbooks, and lecture method chalkboards which are less motivating.

4.8 Suggested ways of overcoming the barriers

Pupils suggested various ways of overcoming the barriers. These include the school purchasing more computers than relying on those that were donated *"…by President Mugabe…"* [the then President of Zimbabwe] as ICT support for schools. Pupils suggested that they be allowed to use their smartphones on the school premises and the school to allow them to access the internet even if an amount is charged on school fees to support their learning as most books are now expensive but good sources are free online as pupils said.

4.9 Recommendations to ordinary level Chemistry teachers looking to integrate ICT into their teaching

The general recommendations from the educators who were interviewed were that;

4.9.1 Training and Adaptation to ICT

The research respondents said teachers who look forward to integrating ICT into their practice should opt to train how to use the gadgets so that they administer them well. They also said there is a need to adapt to the technological changes associated with ICT.

4.9.2 Advocate for clear ICT policies

The respondents recommended that teachers should advocate for clear policies specific to Chemistry and ICT in schools to promote and guide the use of teaching and learning of the subject in secondary schools.

4.9.3 Curriculum development to suit ICT

Respondents said the Chemistry curriculum should be aligned to suit modern forms of digital learning which makes use of virtual labs, visualisations and simulations. The popular view among teachers was that the school library should be equipped with ICT gadgets and the internet to support students' and teachers' research in the field of Chemistry.

4.10 Modification of the Chemistry Syllabus to incorporate ICT effectively

4.10.1 Provision of local online resources

Both FGD and interview respondents reported that there is a need to provide online resources aligned to the syllabus topics which can help pupils and teachers to fully utilize the ICT facility. Adam said:

> *"We need free [digital][text]books, reading materials, [typical exam] question papers and answers for previous examination questions like other exam boards do. We need enough resources to answer all exam questions relating to local context and pure Chemistry because the examination covers the whole syllabus and the syllabus has suggested reading materials".*

Nomalanga added:

> *"Our schools do not afford to buy apparatus and chemicals that are required to carry out experiments. If the examination board site had videos for virtual experiments, it would help less-resourced and marginalised schools so that they supplement reading and teaching materials".*

The study respondents indicated that the authorities especially the examination board [ZIMSEC] should avail online resources for free so that teachers and candidates have access to experiments for different topics, textbooks and typical examination questions as part of the integration of ICT in the ordinary level Chemistry subject and e-learning which can aid in pupils' continuous learning, homework and projects.

4.10.2 Use of software that allows simulation

A respondent said several sections in the syllabus indicate that schools can use simulations. Respondents said due to the lack of physical resources, it would be better for the schools through the Curriculum Development Unit (CDU) to provide the resources as they usually do.

> *"Simulations software to demonstrate experiments and chemical reactions is available and free online for some free educational sites. The only thing required is the school's support to provide teachers with an internet connection. The CDU can also provide the same materials as they do for a lot of teaching and learning aids".*

The respondents' view is in tandem with the reviewed literature where Gupta (2023) indicated that there is a variety of software which helps with virtual experiments and virtual labs. These are deemed to reduce the costs of buying apparatus and chemicals which are expensive. Therefore, ICT helps to have experiments done virtually.

4.10.3 Pre-service equipping teachers with ICT knowledge

Some views pointed to the fact that it would be pertinent to focus on equipping the Chemistry teachers first with ICT knowledge at the college level, thus pre-service training of pedagogical skills so that they constructively integrate technology into their classroom instruction. Musa said:

> *"Teacher education should have courses that have ICT so that teachers learn to develop lessons and integrate ICT and engage students in a meaningful way during lessons [than training old dogs new tricks, (training teachers in service on how to use ICT)]. Also, when someone knows how to use the ICT products, they can plan their lessons involving the ICTs rather than blindly incorporating ICT into their teaching".*

The respondent's view shows that there is a need to train pre-service teachers on how to use technology in lessons so that they come for service fully equipped for using digital technologies.

4.11 Chapter Summary

This chapter presented the data from the responses of respondents obtained from the interview and focus group discussion. An interpretivist approach was used to present, interpret and discuss the findings from the research. Chapter five focused on discussion, conclusions and recommendations.

CHAPTER 5
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the research. Based on the findings from the data gathered during the interview and focus group discussions, conclusions will be made in this chapter on every research question which was raised in chapter one of this research. The chapter also presents recommendations following gaps discovered during the research. Recommendations for the use of ICT in teaching Chemistry ordinary Level and recommendations for further study are also given in this chapter.

5.2 Summary of the study

The study adopted a qualitative research design of data collection and some quantitative techniques were used in analysis. The study population comprised twenty participants. The study sample was selected using purposive sampling and convenience sampling techniques. In-depth interviews and focus group discussions were used as data collection instruments.

The objectives of the study were to (i) assess the current level of ICT utilization in Chemistry teaching at Chamanhanzva High School, (ii) investigate the effects of ICT on student engagement, understanding, and performance in Chemistry and (iii) identify the best practices and recommendations for effective ICT integration in Chemistry education.

The research methodology used was a qualitative approach and a case study design. An interpretivist paradigm was used together with the phenomenological and constructivist approaches to interpret and explain the subjective meanings of the study participants. A sample of 20 people was selected from a population of about 200 people. Non-probability sampling technique was adopted and purposive and convenience sampling were employed. Research data was collected using interviews and Focus Group Discussions. Data was analysed qualitatively using research objectives, themes from reviewed literature as guidelines and themes that arose from the respondents' views. Some quantitative techniques were used to present research data though qualitative techniques were used to interpret data.

The key findings of the research revealed that the use of ICT in the teaching and learning of ordinary level Chemistry at Chamanhanzva Secondary School has resulted in enhanced engagement and motivation of pupils in their studies. This research established that ICT use in the teaching of ordinary level Chemistry resulted in increased pupils' understanding of Chemistry concepts and promoted a learner-centred approach to learning, improved pass rate, motivation to learn and others. On the other hand, there are some negative ramifications that

respondents associated with the use of ICT which include plagiarism, dependency on gadgets, and distraction from learning among others. However, the findings from this research revealed that the current level of utilisation of ICT gadgets and Chamanhanzva Secondary School is very low and the major challenges to the low usage were compounded by a combination of some teachers' lack of ICT proficiency and learners' lack of gadgets and ICT proficiency in juxtaposition of the school's challenges of limited resources and harsh school policies on the use of ICT gadgets in the school.

The research participants suggested some best practices for effective integration of ICT into the teaching and learning of ordinary level Chemistry. The best practices suggested include advocacy for progressive ICT policies that promote the usage of ICTs in the teaching and learning of Chemistry. Other recommendations were the promotion of uploading chemistry teaching and learning resources on the internet for access by both teachers and learners respectively and to address the concerns in a local and culturally relevant manner. Moreover, respondents reported that there is need for schools to work towards increasing ICT gadgets in schools and making software for simulations and experiments available. Above all, the participants said there is a need to integrate the learning of using ICT in the pre-service teacher training programmes and also train those in service to ensure that they confidently use ICT in their teaching practice.

In as much as the research covered intended areas as per set research objectives, there are some limitations which would impact slightly negatively on the generalisation of the study results. The limitations faced include time constraints involving gathering data and analysing research data racing against time, some important issues could have been left out during data collection and analysis. The researcher countered this by effectively managing the time available and making use of a research assistant in data gathering. Another potential limitation was the reluctance of participants to bring out the information and the researcher managed to probe them to say out their views without censoring and with researcher bias.

5.3 Conclusions

5.3.1 What is the current level of ICT utilization in Chemistry teaching at Chamanhanzva High School?

Based on the findings of this research, there is a very limited use of ICT in the teaching of ordinary level Chemistry at Chamamnhanzva Secondary School. A significant number of the teachers reported that they were nearly illiterate in ICT usage in teaching and preferred traditional methods of teaching Chemistry. There seems to be gendered use of ICT where the

male gender dominates the use of ICT in the teachers' fraternity and the same trend seems to be occurring in the pupils where boys dominate the show of using ICT gadgets compared to girls. Respondents lamented using their hard-earned gadgets for teaching and the school has no gadgets specifically for Chemistry, a noble subject that is like oxygen which mixes with any element, the same relates to Chemistry being applied in every avenue of human life but has roots in the secondary education level. Low-level utilisation has reportedly been blamed on the lack of supply of ICTs from the textured with the reluctance of teachers to use the ICTs and pupils' marginalisation in terms of access to ICT resources. This research, therefore, concluded that there is low-level utilisation of ICT in the teaching and learning of ordinary level Chemistry at Chamanhanzva and the issue is complex as it is multifaceted ranging from blame on the school for lack of support, the lack of proficiency in ICT and gendered use of ICT in both teachers and pupils populations, thus forcing the teachers to rarely using ICT, especially in the school, but rather heavily depending on 'risky' social media as the chief ICT tool to communicate with pupils and sending teaching and learning. This leaves teachers and pupils vulnerable to abuse bidirectionally.

5.3.2 How does ICT impact student engagement, understanding, and performance in Chemistry?

A plethora of effects which positively and negatively affect student engagement, understanding, and performance in Chemistry have been discovered in this research findings. The positive impact of the use of ICT includes the idea of changing the perceptions and attitudes of pupils which translates to improved Chemistry lesson attendance due to the experience of ICT gadgets. Other positive impacts include creativity and higher-order thinking as a result of interfacing with multimedia and ICTs. Better still were deemed to create independent learners and a classic pupil-centred class of Chemistry promoting student excellent engagement, their understanding of Chemistry and directly correlating with increased performance. The negative ramifications of the use of ICT in student engagement, understanding, and performance in Chemistry are plagiarism and cheating, where pupils are bound to take other scholars work without acknowledging the sources or when they just repeat the stuff they get from the internet and blindly submit to unsuspecting teachers who reward them for hard work because of the lack of the ICT knowledge. Also, the mere fact of using smartphones has been seen as a chief route militating against inclusivity through the promotion of social stigma and discrimination. Sources of stigma and discrimination emanate from the ownership of phones and types of phones on top of whether the phone has data or airtime. All this puts pressure on innocent pupils and results in discrimination against other marginalised

and less privileged pupils. The eruption of discrimination divides the class and therefore hampers the achievement of good results, motivation and engagement. This research therefore concluded that ICT has the potential to promote pupil engagement, and understanding of taught concepts in Chemistry and ultimately boost the performance of pupils. As such ICT acts as a double-aged sword when applied to student engagement, understanding, and performance in Chemistry depending on the nature of the pupils using the gadgets, especially smartphones and computers.

5.3.3 What are the best practices and recommendations for effective ICT integration in Chemistry education?

The best practices as respondents of this research outlined spanned from policy influence to accommodate Chemistry-specific ICT policies for secondary school education. Also, respondents said the government should prioritise the inclusion of ICT training for pre-service teachers and in-service training for those who need manpower development. Other smart approaches cited include the formation of the Chemistry Teachers Association as a platform for peers to share and sharpen ICT skills. Respondents also said it is sacrosanct for the authorities to make sure there is provision of electronic libraries to allow access to teaching and learning resources for Chemistry as other named examination boards upload their past examination material and suggested resources which makes it easy for pupils and teachers to grasp and living abreast with current trends in ICT. Considering that the school is in a rural setting with less privileged pupils, the chief recommendation was that the responsible authorities would provide the ICT gadgets for use in schools. This study also found that there is a need to modify the Chemistry Syllabus to accommodate the reality of practice, thus allowing software which is used in the real world to be practically used in school Chemistry classes. The current research concluded that best practices and recommendations for the effective utilisation of ICT in Chemistry lessons are inseparable, therefore, best practices need a concerted effort to achieve and a multisectoral approach as the problem seemingly looks sandwiched by many factors.

The concerted approach needs to include teachers' professional development, careful selection of the ICT tools that match the Chemistry learning objectives, student engagement, and interactive learning that enhances pupils' understanding and retention. The research also concluded that it is quintessential to ensure that ICT should serve as a complement to traditional teaching methods, rather than a replacement, hence fostering a blended learning environment that caters to diverse learning styles of pupils from diverse backgrounds.

5.4 Recommendations

The following are recommendations which are based on the findings from this research:

5.4.1 A joint effort from stakeholders to provide ICT for schools' Chemistry class

There is a need for stakeholders in education such as industries dealing with chemicals, government ministries, School Development Committees, Private and Voluntary Organizations and philanthropists to join hands in procuring necessary Chemistry subject ICT material resources in schools to promote learning Chemistry using ICT in preparation of real-life situations where Chemistry is applied.

5.4.2 Funding from the government for Chemistry teachers to attend ICT Chemistry seminars

The government should make funds available and sponsor the teachers' attendance at conferences, seminars and workshops on Chemistry subject material resource production utilisation and management. Also, teachers and pupils may visit areas where ICT in Chemistry is applied so that they familiarise themselves with real-life applications of chemical technology.

5.4.3 Pupils' familiarisation with software use in Chemistry

The study recommends that schools use various software used in Chemistry such as Chemists software. Schools may upload the software to school computers and pupils practice that on relevant topics. These softwares are used for carrying out different chemical research activities such as molecular modelling, simulation, chemical analysis, 2D and 3D visualization of chemical structures, searching databases for Computational chemistry and many more.

5.4.4 Buying low-cost ICTs for Chemistry classes

In schools where resources are limited and school budgets constrained, Chemistry subject teachers should select the cheapest available ICT equipment for the demonstration or illustration of principles and concepts in teaching. The functionality and duration of equipment should be taken into consideration as well.

5.4.5 Provision of free or affordable internet and tablets and/ or laptops to schools

There is a need for the Ministry of Primary and Secondary Education to provide free or affordable internet and gadgets that access the internet subsidised by the government and tablets to bridge the gap between the marginalised and the privileged schools and pupils to promote research and learning in the field of Chemistry. This can ensure and encourage consistent use of ICT tools in the school.

5.4.6 Recommendations for further research

5.4.6.1 Gamification of learning of Ordinary level Chemistry

Examining the role of gamified learning platforms in increasing student engagement and motivation in Chemistry education for beginners on the subject.

5.4.6.2 The effectiveness of virtual laboratories

Investigating the effectiveness of virtual laboratories and simulations in enhancing students' understanding of complex chemical concepts as part of ICT in learning Chemistry.

5.4.7 Recommendations for future work

In line with the findings and gaps discovered in this research, the following areas are recommended for future research:

5.4.7.1 Assess the impact of school-based policies on the use of ICT gadgets Chemistry learning area

There is a need for future research to assess how school-based ICT policies impact the teaching and learning of Chemistry in secondary schools.

5.4.7.2 Social justice in access to ICT in teaching and learning of Chemistry

Research needs to explore the current levels of ICT usage in Zimbabwean secondary schools and interventions to ensure schools and students have equal access to ICT resources.

5.4.7.3 Developing working models for ICT implementation in the teaching and learning of Chemistry

Educational researchers to develop working models or frameworks for effective implementation of ICT in secondary schools in Zimbabwe.

5.6 Chapter Summary

This chapter presented the summary of the study. Conclusions were made in on every research question which was raised in chapter one of this research. The chapter also presented recommendations on gaps noted during the research. Recommendations for further study were also given in this chapter and the areas for future research were highlighted in this chapter.

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Appendices

Appendix 1: Interview Guide for Teachers

1. **How frequently do you integrate ICT in your Chemistry lessons?**

-How frequently do you integrate ICT in your ordinary level Chemistry lessons?

-What specific ICT tools and resources do you currently use in your ordinary level Chemistry classes?

-In what ways has ICT changed your approach to teaching ordinary level Chemistry?

2. **The effects of ICT on student engagement, understanding, and performance in Chemistry**.

-Can you describe a specific instance where an ICT tool made a Chemistry lesson more engaging for you?

-In what ways have ICT tools helped you deliver complex ordinary level Chemistry concepts better in your lessons and practical lessons?

-Have you noticed any changes in your pupils' academic performance in Chemistry since the integration of ICT in your teaching process?

3. **Best practices and recommendations for effective ICT integration in Chemistry education.**

-What are some of the best practices you have observed or implemented for integrating ICT in ordinary level Chemistry education?

-Based on your experience, what recommendations would you give to ordinary level Chemistry teachers looking to integrate ICT into their teaching?

-How should secondary school Chemistry curricula be designed or modified to incorporate ICT effectively?

Appendix 2
Focus Group Discussion for Pupils

1. **The current level of ICT utilization in Chemistry**

-What types of ICT tools have you found most effective for understanding complex Chemistry concepts?

-How have ICT tools changed the way you approach problem-solving in Chemistry?

-What is your level of access to ICT resources for Chemistry learning outside of the classroom?

2. **The effects of ICT on student engagement, understanding, and performance in Chemistry.**

-How has the use of ICT tools like simulations, online quizzes, and interactive modules affected your engagement in Chemistry classes?

-How do you interact with peers using ICT tools in Chemistry? What platforms or methods do you find most effective?

-What role does ICT play in your motivation and interest in continuing to study Chemistry?

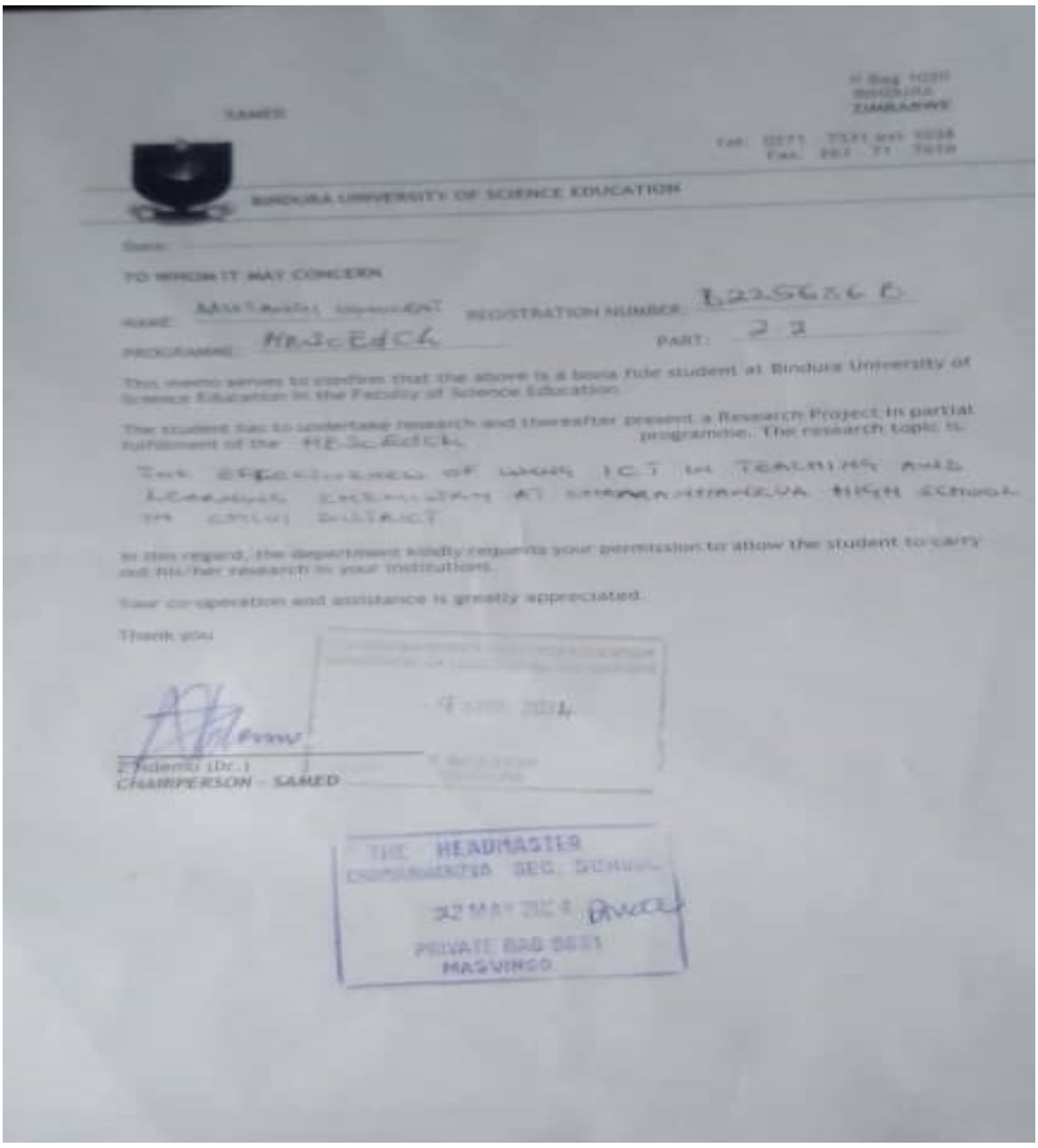
3. **Best practices and recommendations for effective ICT integration in Chemistry education.**

-What are the common barriers to effective ICT integration in Chemistry teaching, and how can they be overcome?

- What best practices have you observed or implemented in integrating ICT into Chemistry education?

- Looking to the future, what recommendations would you make for the continued integration of ICT in Chemistry education?

Appendix 3
Letter of research from Bindura University



BINDURA UNIVERSITY OF SCIENCE EDUCATION

TO WHOM IT MAY CONCERN

REGISTRATION NUMBER: B225626B

PART: 2 2

PROGRAMME: MPSc Ed Ch

This memo serves to confirm that the above is a bona fide student at Bindura University of Science Education in the Faculty of Science Education.

The student has to undertake research and thereafter present a Research Project in partial fulfillment of the MPSc Ed Ch programme. The research topic is:

THE EFFECTIVENESS OF USING ICT IN TEACHING AND LEARNING CHEMISTRY AT SHAMVA/HWEDZA HIGH SCHOOLS IN GOKWE DISTRICT

In this regard, the department kindly requests your permission to allow the student to carry out his/her research in your institutions.

Your co-operation and assistance is greatly appreciated.

Thank you

Mr Ndemiri (Dr.)
CHAIRPERSON - SAMED

THE HEADMASTER
CHIPINGANYIMA SEC. SCHOOL
PRIVATE BAG 9851
MASVINGO