BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

Learners Perspectives on the Opportunities and Challenges of Integrating ICT in Learning and Teaching Chemistry

By

JOSIPHINE MURATO

B224231B

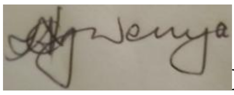
A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DIPLOMA IN SCIENCE EDUCATION.

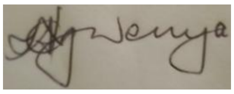
YEAR: JULY 2025

Approval Form

The undersigned certify that they have supervised the student in the research dissertation entitled, “Learners Perspectives on the Opportunities and Challenges of integrating ICT in learning Chemistry” submitted in partial fulfillment of the requirements for a Diploma in Science Education at Bindura University of Science Education.

STUDENT: Josiphine Murato DATE: 10/07/25

SUPERVISOR: Mr  **DATE:10/07/25**

CHAIRPERSON: Mr  **DATE:10/07/25**

Declaration

I hereby declare that this thesis has been the result of my own original efforts and investigations and such work has not been presented elsewhere for the purpose of degree assessment. All additional sources of information have been acknowledged by means of references.

Student Name: Josiphine Murato

Signature: 

Date: 10/07/25

Dedication

This dissertation is lovingly dedicated to my parents, Mr. and Mrs. Murato, whose unwavering belief in my potential and constant encouragement have been my guiding light. Your sacrifices and support have made this academic achievement possible.And to all aspiring Biology students, may you find inspiration and overcome challenges to achieve your full potential.

Acknowledgments

I am deeply thankful to God Almighty for granting me the strength and good health needed to see this research project through to the end. I also wish to sincerely acknowledge my research supervisor, whose unwavering support, guidance, and encouragement were crucial to the successful completion of this work. To my loved parents and siblings, your constant life in me and your support mean more than words can express. May God bless you abundantly.

Abstract

This study explored the perspectives of secondary school learners in Karoi District, Zimbabwe, regarding the integration of Information and Communication Technology (ICT) in chemistry education. Motivated by persistent barriers to ICT utilization in rural schools, the research aimed to examine learners' experiences, perceived benefits, and the challenges they face in ICT-supported chemistry learning. A mixed-methods case study design was employed, combining questionnaires, focus group discussions, and academic record analysis. Data were collected from 30 learners enrolled in Forms 3 and 4 chemistry classes. Quantitative data were analyzed using descriptive statistics, while qualitative responses were examined thematically. Findings revealed that learners viewed ICT as a powerful tool for enhancing understanding, motivation, and access to educational resources—particularly through visual aids and online content. However, challenges such as inadequate infrastructure, limited teacher support, policy restrictions on device use, and inconsistent access to relevant chemistry software were significant barriers. The study concludes that effective ICT integration in rural schools requires a learner-centered approach supported by adequate resources, teacher training, and infrastructure development. Recommendations include targeted investments in digital tools, inclusive school policies, and continuous capacity-building initiatives for teachers to enhance chemistry teaching through technology.

List of Figures

List of Tables

List of Abbreviations

B.Ed.: Bachelor of Education

HOD: Head of Department

ICT: Information and Communication Technology

MoPSE: Ministry of Primary and Secondary Education (Zimbabwe)

M.Sc.: Master of Science

N: Sample Size (in tables/figures)

O'Level: Ordinary Level

PCK: Pedagogical Content Knowledge

PGDE: Post Graduate Diploma in Education

PTA: Parent-Teacher Association

RBV: Resource-Based View

SCT: Social Cognitive Theory

SDC: School Development Committee

SES: Socio-Economic Status

SPSS: Statistical Package for Social Sciences

STEM: Science, Technology, Engineering, and Mathematics

ZIMSEC: Zimbabwe Schools Examination Council

Table of Contents

CHAPTER ONE: THE PROBLEM AND ITS SETTING

1.1 Introduction

Information and Communication Technology (ICT) has fundamentally reshaped global education, offering interactive simulations, virtual laboratories, and molecular modeling tools that clarify abstract chemistry concepts such as reaction kinetics and equilibrium (Dori et al., 2008; Aksela & Ferk Savec, 2020). Despite policy commitments, notably Zimbabwe's 2015–2022 Curriculum Framework which prioritizes ICT literacy across subjects (MoPSE, 2015), practical implementation often falls short, especially in rural schools.

A secondary school in KaroiDistrict exemplifies this disparity: infrastructural constraints, limited technical support, and erratic power and internet access hinder consistent ICT integration in chemistry instruction. Crucially, learners' experiences—how they navigate these challenges and perceive ICT's impact on their understanding and motivation—remain underexplored. Grounded in the Faculty of Science Education at Bindura University of Science Education (BUSE), this study foregrounds learner voices to generate user-centred insights. By examining students' perceived opportunities and barriers to ICT use in chemistry, the research aims to inform targeted interventions, refine policy, and enhance teacher education programs.

1.2 Background of the Study

The integration of ICT into educational frameworks is not a recent phenomenon, but its depth and sophistication have accelerated dramatically in the 21st century, reshaping pedagogical possibilities. Globally, educational research consistently highlights the positive impact of well-implemented ICT strategies on student engagement, motivation, and conceptual understanding, particularly in STEM (Science, Technology, Engineering, and Mathematics) fields (Teo et al., 2008; Dori et al., 2008). Within chemistry education specifically, a rich array of ICT tools has been developed and deployed. These include interactive simulations (e.g., PhET simulations) that allow students to manipulate variables in virtual experiments; molecular visualization software (like ChemDoodle or Jmol) for exploring 3D structures; virtual labs providing safe alternatives for hazardous experiments; data logging equipment for real-time analysis; and collaborative platforms facilitating group work. Theoretically, the use of such tools aligns well with constructivist learning theories, which emphasize active knowledge construction by the learner through interaction and exploration (Aksela & Ferk Savec, 2020).

In Zimbabwe, the national commitment to harnessing these technologies is unequivocal, as enshrined in the MoPSE Curriculum Framework (2015) and supported by initiatives like the Presidential Computerization Programme. The stated goal is not merely to provide hardware but to foster an environment where ICT becomes an integral part of the teaching and learning fabric, cultivating essential digital literacy and higher-order thinking skills (Mpofu et al., 2016). However, the journey from policy to effective pedagogical integration faces substantial headwinds, particularly in rural schools. Challenges include maintenance, software updates, inadequate teacher training focused on pedagogical integration, and the prohibitive costs of reliable internet and electricity (Eilks et al., 2018).

Rural educational institutions, such as the secondary school in this study, exist at the sharp end of these implementation challenges. They frequently contend with infrastructural deficits that fundamentally constrain ICT usage. Unreliable electricity, poor internet connectivity, and an insufficient number of functional computers create significant logistical hurdles. Furthermore, the availability of appropriate, curriculum-aligned chemistry software and localized technical support is often lacking.

While numerous studies have explored ICT integration, many focus on infrastructural audits or teacher perspectives in well-resourced urban settings. Research specifically capturing the nuanced perspectives of learners regarding their day-to-day experiences with ICT in a conceptually demanding subject like chemistry remains comparatively scarce within the Zimbabwean context. Learners are uniquely positioned to articulate how technology practically impacts their learning process. Their perspective provides an essential reality check on the effectiveness of implemented strategies and highlights barriers that might be less visible to educators or policymakers. This study aims to address this specific empirical gap.

1.3 Statement of the Problem

Chemistry education often challenges learners due to its abstract nature and reliance on symbolic representation. ICT holds promise for overcoming these challenges through interactive visualizations and simulations (MoPSE, 2015), yet a disconnect persists between policy aspirations and rural classroom realities. Learners at a secondary school in Karoi District encounter multiple obstacles: limited device access, unstable power and internet, a lack of relevant chemistry software, and minimal integration of ICT into lessons. These constraints impede their ability to leverage technology for understanding molecular structures, reaction mechanisms, and data analysis. The central problem is the lack of empirically grounded insight into how these learners perceive and navigate ICT integration in chemistry within a resource-constrained setting. Addressing this gap is crucial for developing evidence-based strategies that align policy goals with classroom practice, thereby improving student engagement and achievement.

1.4 Assumptions of the Study

This study is based on the following assumptions:

- The participants (learners) will provide honest and thoughtful responses to the data collection instruments.
- The learners at the selected school have had some level of exposure to ICT, however minimal, in their educational context.
- The perspectives gathered from the learners are a valid representation of their experiences and attitudes towards ICT in chemistry education.

1.5 Research Questions

This study is guided by the following research questions:

1. How do learners at the school perceive the opportunities and challenges of ICT integration in chemistry education?
2. What are the learners' attitudes towards using ICT tools for learning chemistry?
3. How do these attitudes influence their motivation and perceived academic performance in chemistry?

1.6 Objectives of the Study

The objectives of this study are to:

1) Explore the opportunities and challenges of ICT integration in chemistry education from the learners' perspective at a secondary school in Karoi District.
2) Investigate the attitudes of learners towards the use of ICT tools in their chemistry education.

3) Examine the perceived impact of ICT on learners' motivation and academic performance in learning chemistry.

1.7 Significance of the Study

The findings of this research are anticipated to hold considerable significance for several key stakeholders:

For Learners: This study offers a direct conduit for learner voices to be heard. The findings can lead to practical adjustments in the classroom that better reflect their needs and challenges, potentially improving their engagement and learning experience.

For Educators and School Administration: The research will provide invaluable, context-specific feedback, enabling teachers and school leaders to better understand which ICT approaches are working and why. This can inform practical adjustments, such as refining timetabling for computer lab access, identifying specific software needs, or advocating more effectively for necessary resources.

For Policymakers (MoPSE, District Education Inspectorate): The study provides crucial ground-level data that moves beyond broad statistics. By highlighting the specific barriers encountered by learners, the research can inform more nuanced and realistic policy formulation, better targeting of resources, and the development of more relevant teacher training modules.

For Bindura University of Science Education (BUSE) and Teacher Training Institutions: The findings can directly inform the curriculum design and pedagogical approaches within BUSE's Faculty of Science Education. It can equip future chemistry teachers with a deeper understanding of the practical challenges they will face and provide them with evidence-based strategies informed by learner experiences.

For the Broader Academic Community: This study contributes valuable empirical data to the body of knowledge concerning ICT in education, specifically focusing on learner perspectives within a developing country context. It addresses a recognized gap in the literature and can stimulate further comparative research.

1.8 Limitations of the Study

While striving for rigor, this research is subject to certain inherent limitations:

Generalizability: The study employs a case study design focused on a single institution. The findings may not be statistically generalizable to all schools in Zimbabwe, but can offer valuable analytical insights for similar contexts.

Scope of Perspectives: The research deliberately centers on the learners' perspective. It excludes the perspectives of teachers, administrators, and parents, which would offer a more holistic understanding but falls outside the defined scope of this project.

Subject Specificity: The focus is solely on chemistry. Learners' experiences with ICT might differ significantly in other subjects.

Potential Respondent Bias: Learner responses might be influenced by factors such as social desirability or recall bias. Measures will be taken (e.g., ensuring anonymity) to mitigate these factors.

Researcher's Position: As a researcher affiliated with BUSE, awareness of potential unintentional bias will be maintained through adherence to strict ethical and methodological guidelines.

1.9 Delimitations of the Study

To ensure a focused scope, the study is delimited as follows:

Focal Perspective: The study is strictly limited to the perspectives of secondary school learners.

Subject Area: The investigation is confined to the experience of ICT within the subject of chemistry.

Participant Pool: Participants are exclusively learners enrolled at a single secondary school in Hurungwe District, Zimbabwe.

Geographical and Institutional Limit: The research site is delimited to one school to allow for in-depth exploration.

1.9 Definition of Terms

To ensure clarity and consistency throughout this dissertation, the following key terms are operationally defined as follows:

ICT (Information and Communication Technology): Refers specifically within this study to the range of digital tools, hardware (e.g., desktop computers, laptops, tablets, projectors, printers), software (e.g., operating systems, productivity suites, web browsers, specialized chemistry simulation/modelling applications, educational apps), network systems (internet access, local networks), and digital content/resources (e.g., websites, online databases, digital textbooks, videos, tutorials) that learners at a Karoi District Secondary School potentially encounter or utilize, directly or indirectly, to support their learning and communication activities related to chemistry.

ICT Integration (in Chemistry Learning): Defined not merely as the presence or occasional use of technology, but as the purposeful and pedagogically sound incorporation of ICT tools and resources into the regular teaching and learning processes of chemistry.

Opportunities (of ICT Integration): Encompasses the potential benefits, advantages, enabling factors, or positive affordances that learners perceive ICT offers or could offer for improving their learning of chemistry.

Challenges (of ICT Integration): Refers to the obstacles, difficulties, barriers, limitations, or constraints that learners perceive hinder their ability to effectively access or utilize ICT for learning chemistry. These can be multifaceted, including infrastructural issues (power, connectivity, device availability/functionality), resource limitations (lack of relevant software/content), logistical problems (access time, technical support), pedagogical factors (how ICT is used in lessons), and personal factors (individual digital literacy levels, lack of access outside school).

Learners' Perspective: Represents the collected views, opinions, attitudes, beliefs, feelings, interpretations, and reported experiences of the secondary school students at a Karoi District Secondary School concerning the role, usability, benefits, and drawbacks of ICT as applied to their chemistry education. This study privileges their subjective understanding and lived reality.

Chemistry Learning: Encompasses the multifaceted process through which learners acquire knowledge of chemical facts and principles (e.g., stoichiometry, periodicity, organic chemistry structures), develop conceptual understanding of core chemical theories (e.g., atomic theory, bonding models, thermodynamics, kinetics), hone practical and cognitive skills relevant to chemistry (e.g., problem-solving, data interpretation, designing experiments, symbolic representation), and foster attitudes associated with scientific inquiry within the specific domain of the chemistry curriculum followed at a Karoi District Secondary School.

Rural School Setting: Defines the specific operational context of a Karoi District Secondary School, characterized by its location in Karoi, Hurungwe District, an area geographically distant from major urban centers. This setting typically implies factors pertinent to ICT integration such as potential limitations in reliable electricity supply, variable and often costly internet connectivity, reduced access to specialized technical support personnel, possibly fewer financial resources compared to urban counterparts, and a distinct community socio-economic profile that may influence learners' out-of-school access to technology.

1.10 Dissertation Layout

Chapter 1: Introduction: This current chapter sets the stage for the entire study. It introduces the research topic, provides essential background information, defines the core research problem, articulates the specific research questions and objectives guiding the inquiry, outlines the study's significance for various stakeholders, acknowledges its limitations and defines its boundaries (delimitations), provides operational definitions for key terminology, and concludes with this overview of the dissertation structure.

Chapter 2: Literature Review: This chapter delves into existing scholarly work relevant to the research topic. It critically reviews theories and empirical studies concerning ICT integration in education, with a specific focus on science (particularly chemistry) education. It explores literature on learner perspectives regarding technology use, examines documented challenges and opportunities of ICT in rural and developing country contexts, and identifies the theoretical framework underpinning the study, thereby contextualizing the current research within the broader academic landscape.

Chapter 3: Research Methodology: This chapter provides a detailed account of the systematic procedures employed to conduct the research. It outlines the chosen research paradigm, the research design, and the research approach. It describes the target population and the sampling techniques used to select participant learners. Details regarding the data collection instruments, the procedures for data collection, the methods planned for data analysis, and crucial considerations regarding research are meticulously presented.

Chapter 4: Data Presentation, Analysis, and Discussion: This chapter forms the core of the empirical work. It systematically presents the findings derived from the analysis of the data collected from the learners at a Karoi District Secondary School. The presented data are then thoroughly analyzed in direct relation to the research questions posed in Chapter 1. This analysis is further enriched by discussing the findings in the context of the literature reviewed in Chapter 2, highlighting points of convergence, divergence, and unique insights emerging from this specific study.

Chapter 5: Summary, Conclusions, and Recommendations: This concluding chapter synthesizes the entire research project. It begins with a concise summary of the study's purpose, methodology, and key findings. Based on the analysis presented in Chapter 4, it draws logical conclusions that directly address the research questions. Finally, it offers practical and actionable recommendations aimed at improving ICT integration for chemistry learning at a Karoi District Secondary School, potentially informing policy and practice in similar contexts, and suggests pertinent areas for future research stemming from the study's findings and limitations.

1.11 Chapter Summary

This comprehensive introductory chapter has laid the essential groundwork for the investigation into learners' perspectives on ICT integration in chemistry learning at a Karoi District Secondary School. It commenced by establishing the global and national context of ICT in education, emphasizing its particular relevance and potential within chemistry. The significant challenges faced, especially in rural Zimbabwean settings like Mauya, were highlighted, leading to the formulation of the core research problem: the need to understand the lived experiences and views of learners regarding ICT opportunities and challenges in their chemistry education. The specific research questions and objectives guiding the study were clearly articulated. The multi-faceted significance of the research was elaborated, particularly its relevance for the learners and educators at the school, policymakers, the academic community, and notably, for Bindura University of Science Education's mission in science teacher training. The inherent limitations and deliberate delimitations shaping the scope of the research were acknowledged and defined. Key terms central to the study were operationally defined to ensure clarity. Finally, the overall structure of the dissertation, comprising five chapters along with references and appendices, was presented. The subsequent chapter, Chapter 2, will now proceed to critically review the relevant body of existing literature, providing a theoretical and empirical foundation for the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter is central to establishing the foundation for this study by critically examining the evolution, implementation, and impact of Information and Communication Technology (ICT) in chemistry education. It synthesizes existing research to highlight how ICT has transformed educational practices and identifies key gaps that this study seeks to address. The discussion foregrounds the dual nature of ICT as both a catalyst for innovative teaching and a source of new challenges, such as infrastructural deficiencies and disparities in digital literacy.

2.2 Theoretical and Conceptual Framework

A theoretical framework provides a structure to understand, analyze, and interpret research data. It consists of concepts and existing theories that are relevant to the research problem. This study is guided by several key theories that explain technology adoption and its pedagogical implications.

Developed by Davis (1989), the Technology Acceptance Model (TAM) is a widely used framework for explaining user behavior towards new technology. TAM posits that two primary factors—perceived usefulness and perceived ease of use—determine the acceptance and utilization of technology. In an educational context, if learners perceive that a virtual lab improves their understanding of chemistry (usefulness) and is easy to navigate (ease of use), they are more likely to engage with it.

Rogers' (2003) Diffusion of Innovations Theory offers a complementary perspective, examining how new technologies spread within a social system like a school. It identifies key factors influencing adoption, including relative advantage, compatibility, complexity, trialability, and observability. This framework helps explain why ICT might be embraced at different rates, even when its advantages seem clear.

The Unified Theory of Acceptance and Use of Technology (UTAUT), proposed by Venkatesh et al. (2003), integrates elements from previous models to offer a more comprehensive explanation of technology acceptance. It introduces factors such as social influence and facilitating conditions (e.g., available infrastructure and support), which are particularly relevant in rural school contexts where such conditions are often limited.

Finally, Constructivist Learning Theories are crucial for understanding the pedagogical value of ICT. These theories argue that learners actively construct their own knowledge through exploration and interaction. ICT tools like simulations and virtual labs align perfectly with this approach by enabling students to move from passive reception to active, student-centered inquiry (Aksela & Ferk Savec, 2020).

2.3 Global Perspectives on ICT Integration in Education

The integration of ICT into education has evolved significantly over the past few decades. Initially, the focus was on introducing basic computer literacy in schools, but rapid advancements in technology have expanded the scope to include interactive multimedia, online learning platforms, and virtual laboratories. International organizations such as UNESCO have long championed the role of digital technologies in enhancing educational access and quality. According to UNESCO (2013), the effective use of ICT can democratize learning, enabling equitable access to resources regardless of geographic or socio-economic barriers.

Globally, governments and educational bodies have implemented numerous policies to promote ICT integration. For example, the European Union’s Digital Education Action Plan and initiatives by the Organization for Economic Co-operation and Development (OECD) emphasize the need to foster digital skills and create supportive environments for technology-enhanced learning. These policies often focus on teacher training, curriculum development, and infrastructure improvement, which are seen as essential components for successful ICT adoption. In many developing countries, international aid and government-backed programs, such as the Presidential Computerization Program in Zimbabwe, aim to bridge the digital divide and modernize educational systems (Ministry of Primary and Secondary Education, 2015).

Regional disparities in ICT integration are evident when comparing developed and developing regions. In high-income countries, robust infrastructure, widespread internet connectivity, and significant investments in educational technology facilitate rapid and effective integration. Conversely, many low- and middle-income countries face substantial challenges, including limited access to digital tools, inadequate power supply, and insufficient professional development for educators. Studies have shown that while ICT has the potential to transform education, its success is largely dependent on the local context, including socio-economic conditions and governmental support (OECD, 2015). These regional comparisons underscore the necessity for tailored strategies that consider both global trends and local realities.

Global trends in ICT integration have also influenced local educational practices. The proliferation of mobile technology and the increasing accessibility of high-speed internet have enabled even remote and rural areas to benefit from digital learning resources. However, the translation of global best practices into local contexts is not without challenges. Cultural factors, language barriers, and differing pedagogical traditions often require adaptations of international models to fit local needs. For instance, while online learning platforms and digital content libraries have revolutionized access to information in urban centers, rural schools may require customized solutions that account for infrastructural limitations and lower digital literacy levels among learners and educators.

Despite the promise of ICT, significant challenges remain on a global scale. Issues such as digital inequity, the need for sustained funding, and cybersecurity concerns are common across various regions. Moreover, the rapid pace of technological change necessitates continuous professional development for educators and ongoing investments in infrastructure. On the opportunity side, the global emphasis on ICT has spurred innovations in educational technology, resulting in increasingly sophisticated tools that enhance interactive learning, foster collaboration, and support personalized education. These developments offer valuable lessons and models that can be adapted to improve ICT integration in under-resourced settings, including rural schools.

Understanding global perspectives on ICT integration provides a benchmark against which local practices can be evaluated. For rural schools like a Karoi District Secondary School, insights drawn from international trends help identify both the potential benefits and the limitations of digital technologies. By comparing global strategies with local realities, this study aims to uncover the factors that facilitate or hinder effective ICT adoption in rural science education, ultimately contributing to a more nuanced understanding of digital equity and educational innovation.

2.4 ICT Integration in Science Education

The integration of Information and Communication Technology (ICT) into science education has become a transformative force, reshaping traditional pedagogical practices and opening new avenues for teaching and learning. The rapid evolution of digital technologies has enabled the creation of dynamic, interactive, and student-centered learning environments that enhance the comprehension of complex scientific concepts and foster critical thinking skills.

One of the most significant contributions of ICT in science education is the development of interactive simulations and virtual laboratories. These digital tools offer students the opportunity to experiment with scientific phenomena in a safe and controlled virtual environment. For instance, virtual labs allow learners to conduct experiments that might be too costly, dangerous, or impractical in a traditional classroom setting (ScienceDirect, 2011). By simulating real-world experiments, these tools help demystify abstract scientific theories and provide tangible learning experiences that improve conceptual understanding. Additionally, interactive simulations encourage exploratory learning, where students can manipulate variables and observe outcomes, thereby reinforcing the scientific method through practical application.

Beyond simulations, educational software and mobile applications have further enriched science education. Platforms such as Discovery Education and various adaptive learning systems provide multimedia content—including videos, animations, and interactive quizzes—that cater to diverse learning styles. These tools support personalized learning by allowing educators to tailor instructional content to meet individual student needs. Moreover, the use of data analytics in some advanced educational platforms enables the monitoring of student progress in real time, facilitating timely interventions and reinforcing a learner-centered approach (Techjockey, 2024). Such adaptive technologies not only enhance student engagement but also promote a deeper understanding of scientific principles by making learning more interactive and responsive.

Collaborative digital platforms also play a critical role in modern science education. Tools such as Google Workspace and various virtual discussion forums allow students to collaborate on projects, share ideas, and engage in problem-solving activities in real time. This level of collaboration extends beyond the classroom, enabling interactions with peers and experts across the globe. As a result, learners are exposed to a broader range of perspectives and innovative ideas, fostering an environment that mirrors the collaborative nature of contemporary scientific research (Secondary Sparks, 2023). These collaborative efforts help build essential skills, such as communication, teamwork, and digital literacy, which are indispensable in today's interconnected world.

However, despite the substantial benefits of ICT integration, several challenges persist, particularly in under-resourced educational settings. Infrastructure limitations, such as inadequate access to computers, unstable internet connectivity, and a lack of technical support, can severely hinder the effective use of digital tools in science classrooms (ERIC, 2015).

Additionally, the success of ICT integration is highly dependent on teacher preparedness. Many educators require ongoing professional development to acquire the digital skills necessary for implementing technology-enhanced instruction effectively. Without sufficient training, even the most advanced technological tools may fail to translate into improved learning outcomes (Teachers Institute, n.d.). Moreover, aligning ICT resources with existing curricula demands careful planning and adaptation to ensure that technology serves to complement, rather than overshadow, core scientific content.

Looking forward, the opportunities presented by ICT in science education are both exciting and expansive. Emerging technologies such as augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) hold the promise of further revolutionizing science teaching by offering immersive and highly interactive learning experiences. These advanced tools could enable students to explore the microscopic world of cells or the vast expanse of the universe in unprecedented detail, thereby igniting curiosity and driving a deeper engagement with scientific inquiry (Getting Smart, 2018). Furthermore, the global accessibility of digital content facilitates continuous learning beyond the classroom, empowering students to pursue science education at their own pace and according to their interests.

In summary, while challenges such as infrastructural constraints and the need for enhanced teacher training continue to pose significant hurdles, the integration of ICT in science education offers transformative potential. It not only enhances the delivery of scientific content through interactive simulations, adaptive software, and collaborative platforms but also prepares students for the demands of a modern, technology-driven society. The ongoing evolution of digital tools promises to further enrich science education, making it more accessible, engaging, and effective for learners across diverse educational contexts.

2.5 ICT Integration in Rural Education Contexts

Integrating ICT in rural education presents a distinctive set of challenges and opportunities that differentiate it from urban settings. Rural schools often operate under constrained resources, facing infrastructural, socio-economic, and pedagogical hurdles that can impede the effective adoption of digital tools. However, these challenges also pave the way for innovative solutions tailored to local needs, ultimately contributing to bridging the digital divide and enhancing educational outcomes.

A primary challenge in rural contexts is the limited access to reliable infrastructure. Many rural schools struggle with insufficient electricity, inadequate hardware, and poor internet connectivity, which restrict the implementation of ICT-based learning. As Mpofu et al. (2016) highlight, the absence of consistent technological infrastructure means that even when digital tools are introduced, their utilization is often sporadic and ineffective. This infrastructural gap not only hampers the deployment of ICT but also affects the overall reliability and sustainability of any digital intervention.

Beyond infrastructural constraints, rural educators often encounter significant hurdles related to teacher preparedness and digital literacy. Many teachers in rural areas have limited exposure to modern technological tools and digital pedagogies. Without continuous professional development, these educators may find it difficult to integrate ICT seamlessly into their curriculum, thereby limiting its potential benefits. Eilks et al. (2018) emphasize that effective ICT integration requires not only the availability of technological resources but also the capacity of teachers to utilize these tools to create engaging, interactive learning experiences. Professional development and targeted training programs are therefore essential to empower educators with the skills needed to harness ICT effectively.

Socio-economic factors further complicate ICT adoption in rural settings. Students in these environments may have limited access to personal digital devices outside of school and might lack the financial means to engage with ICT resources fully. This digital inequity can result in a significant disparity in learning opportunities between rural and urban students. To address this, government initiatives and community-based programs have been introduced in various regions to provide subsidized or free access to ICT tools. The Ministry of Primary and Secondary Education (2015) outlines several programs aimed at improving ICT access in under-resourced areas, although the implementation and reach of these initiatives often remain inconsistent.

Despite these challenges, the rural context also offers unique opportunities for innovative ICT integration. The relative simplicity and lower cost of mobile technology, for instance, have made mobile-based learning platforms a promising avenue for rural education. Mobile devices are increasingly used to deliver educational content, enabling students to access learning materials beyond the confines of traditional classrooms. Such initiatives not only enhance access but also promote self-directed learning among students who might otherwise be deprived of quality digital education.

Furthermore, the integration of ICT in rural education has the potential to foster community involvement and local ownership of educational innovations. When community members, local government, and educators collaborate to implement digital solutions, the initiatives are more likely to be tailored to the specific needs and cultural contexts of the area. This localized approach can lead to more sustainable ICT integration, as it builds on existing community strengths and resources. Additionally, the use of ICT in rural education can stimulate local economies by creating demand for technical skills and related services, ultimately contributing to broader socio-economic development.

In summary, while ICT integration in rural education is challenged by infrastructural deficits, limited teacher training, and socio-economic disparities, it simultaneously offers significant potential to transform teaching and learning. By addressing these challenges through targeted investment in infrastructure, continuous professional development, and community-based initiatives, rural schools can leverage ICT to provide richer, more engaging educational experiences. This dual focus on overcoming barriers and capitalizing on unique opportunities is crucial for fostering a more equitable and effective digital learning environment in rural settings.

2.6 Empirical Studies on ICT Integration

Empirical research on the integration of Information and Communication Technology (ICT) in chemistry education has generated a diverse body of evidence highlighting both the trans-formative potential of digital tools and the challenges associated with their effective implementation. Studies conducted in various educational contexts have sought to quantify the impact of ICT on student engagement, academic achievement, and the development of digital competencies, while also examining the mediating factors that influence successful adoption.

A significant portion of the empirical literature supports the notion that ICT integration can lead to enhanced learning outcomes. For example, numerous studies have reported that the use of interactive simulations, virtual laboratories, and multimedia resources significantly improves conceptual understanding in science subjects (Dori et al., 2008; Getting Smart, 2018). These digital tools create opportunities for experiential learning by allowing students to engage with abstract scientific concepts in a more tangible and interactive manner. Such studies demonstrate that when ICT tools are aligned with curriculum objectives, they can foster critical thinking, problem-solving skills, and a deeper interest in subject matter.

However, the empirical evidence also reveals that the positive effects of ICT are not uniformly experienced across all educational settings. Research conducted in under-resourced and rural schools often highlights substantial variability in outcomes. For instance, studies by Mpofu et al. (2016) and Eilks et al. (2018) indicate that infrastructural limitations, such as inconsistent power supply and poor internet connectivity, can significantly constrain the effectiveness of ICT initiatives. These studies show that while the introduction of digital tools has the potential to transform learning environments, the lack of robust infrastructure and adequate technical support often results in sporadic usage and diminished educational benefits.

Furthermore, teacher preparedness has emerged as a critical factor influencing the success of ICT integration. Empirical investigations have found that educators' digital literacy and confidence in using technology directly impact the quality of ICT-based instruction. In many cases, insufficient professional development and training hinder teachers from fully exploiting the capabilities of digital tools, leading to suboptimal learning experiences (Teachers Institute, n.d.; ERIC, 2015). This finding underscores the need for continuous professional development programs that equip educators with the skills required to integrate ICT effectively into their teaching practices.

Another dimension explored in empirical research is the role of socio-economic factors in shaping ICT outcomes. Studies have demonstrated that digital inequity persists, with students from lower socio-economic backgrounds often having limited access to personal digital devices and reliable internet outside of the classroom. This digital divide exacerbates existing educational disparities and affects the overall impact of ICT initiatives (UNESCO, 2013). As a result, several empirical studies advocate for targeted interventions, such as subsidized technology programs and community-based initiatives, to ensure equitable access to digital learning resources.

Notably, some longitudinal studies have provided insights into the sustained impact of ICT on educational performance. Research by Venkatesh and Davis (2000) and subsequent studies under the Unified Theory of Acceptance and Use of Technology (UTAUT) framework indicate that over time, consistent exposure to ICT can lead to improvements in digital competencies, greater student autonomy, and enhanced collaborative skills. These studies suggest that while short-term gains might be modest, the long-term benefits of integrating ICT can be profound when supported by appropriate infrastructure, teacher training, and policy frameworks.

In summary, empirical studies present a nuanced picture of ICT integration in education. While digital tools offer promising avenues for enhancing learning and engagement, their success is heavily contingent upon the interplay of infrastructural, pedagogical, and socio-economic factors. These findings highlight the importance of context-specific strategies and sustained investments in technology and professional development. By addressing these mediating factors, educators and policymakers can better harness the potential of ICT to transform educational practices and promote equitable learning opportunities.

2.7 ICT Integration in Zimbabwean Education Policies

Zimbabwe has recognized the pivotal role of Information and Communication Technology (ICT) in modernizing its education system and aligning it with global standards. Over the past two decades, the country has developed and implemented several policies aimed at integrating ICT into education to enhance teaching and learning processes.

In 2005, Zimbabwe adopted its National ICT Policy, which underscored the importance of incorporating ICTs across various sectors, including education. This policy was informed by earlier initiatives such as the Nziramasanga Education Commission Report of 1999, which recommended the use of computers in educational institutions, and the National Science and Technology Policy of 2002. The 2005 policy laid the groundwork for promoting ICT infrastructure and digital literacy within schools.

Building upon this foundation, the Ministry of ICT, Postal, and Courier Services released an updated National ICT Policy in 2016, which was officially launched in 2018. This policy acknowledged the critical role of ICTs in the education sector and aimed to integrate technology to improve educational outcomes. Subsequently, the Ministry of Primary and Secondary Education introduced the ICT Policy for Primary and Secondary Education (2019–2023), reflecting the government's commitment to embracing technology in education.

Despite these policy advancements, challenges persist in the effective implementation of ICT in Zimbabwean schools. Factors such as limited infrastructure, inadequate teacher training, and socio-economic disparities have hindered the widespread adoption of ICT tools in classrooms. To address these issues, the government has collaborated with various stakeholders to enhance digital literacy and infrastructure, aiming to create an environment conducive to effective ICT integration in education .

In summary, Zimbabwe's education policies have progressively emphasized the integration of ICT to modernize and improve the quality of education. While significant strides have been made in policy formulation, ongoing efforts are required to overcome implementation challenges and fully realize the benefits of ICT in education.

2.8 Research Gaps and Implications for the Current Study

Empirical and theoretical literature on ICT integration in education has generated a substantial body of knowledge; however, several critical research gaps remain that warrant further investigation. One significant gap is the limited focus on the learner's perspective. While many studies have examined teacher preparedness, curriculum alignment, infrastructural constraints, and policy frameworks (Dori et al., 2008; Mpofu et al., 2016; Eilks et al., 2018), relatively few have centered on how students experience and perceive the integration of digital tools into their learning environments. This oversight leaves unanswered questions about the extent to which ICT initiatives truly resonate with, and benefit, the primary recipients of educational innovations—namely, the learners.

Another notable gap is the scarcity of context-specific research in rural education settings. Much of the existing literature derives from studies conducted in urban or well-resourced environments, where access to technology, internet connectivity, and supporting infrastructure is more readily available. In contrast, rural schools, especially in developing countries like Zimbabwe, face unique challenges such as limited infrastructure, socio-economic constraints, and lower levels of digital literacy among both students and educators. These factors can significantly impede the effective integration of ICT, yet their interplay in shaping educational outcomes in rural contexts remains underexplored. Without an in-depth understanding of these dynamics, it becomes challenging to design targeted interventions that address the specific needs of rural learners.

Additionally, the rapid pace of technological evolution poses another gap in the current literature. Many empirical studies rely on data that may no longer capture the current technological landscape, where emerging tools such as mobile learning applications, virtual laboratories, augmented reality (AR), and artificial intelligence (AI) are beginning to play a transformative role in education. This lag between technological innovation and academic research means that our understanding of the benefits and challenges associated with these new digital tools is still evolving. Consequently, there is a need for updated research that reflects contemporary developments and assesses their impact on teaching and learning, particularly in science education.

Moreover, the influence of socio-cultural factors on ICT integration is an area that has not been thoroughly investigated. Cultural attitudes toward technology, community support structures, and local educational traditions can profoundly affect how digital tools are adopted and utilized in the classroom. However, many studies have treated these factors as secondary to more technical or pedagogical issues. This narrow focus limits our understanding of how broader social dynamics contribute to the success—or failure—of ICT initiatives, especially in rural settings where cultural context plays a critical role.

The implications of these research gaps are far-reaching. The current study aims to address these shortcomings by specifically focusing on the learner's perspective within a rural educational context. By exploring how students at a Karoi District Secondary School experience ICT integration in their science education, this research seeks to fill a critical void in the literature. The study will investigate key issues such as access to digital tools, the effectiveness of interactive learning environments, and the overall impact of ICT on academic performance and motivation among rural learners.

Furthermore, the insights generated from this research are expected to inform both policy and practice. By highlighting the unique challenges and opportunities associated with ICT integration in rural science education, the study will provide evidence-based recommendations for policymakers, educators, and other stakeholders. These recommendations may include strategies for enhancing teacher training, improving infrastructural support, and fostering community partnerships—all aimed at bridging the digital divide and creating more inclusive, effective learning environments.

In summary, while the existing literature demonstrates the potential of ICT to transform education, significant gaps remain—particularly regarding the experiences of rural learners and the contextual challenges they face. Addressing these gaps is essential for developing targeted, sustainable solutions that fully harness the benefits of digital tools in enhancing science education. The current study, by focusing on these issues, aspires to contribute meaningfully to the discourse on ICT integration and to pave the way for more effective educational interventions in under-resourced settings.

2.9 Chapter Summary

This chapter synthesizes literature on ICT integration in education, emphasizing science education in rural contexts through theoretical frameworks like TAM, Diffusion of Innovations, and UTAUT, which highlight factors such as usability, social influence, and pedagogical alignment. Globally, ICT has evolved from basic digital literacy to advanced tools like virtual labs, yet rural areas face infrastructural deficits, limited teacher training, and socio-economic disparities, as seen in Zimbabwe's policy efforts struggling with implementation. ICT tools enhance science learning through simulations and collaborative platforms, but their effectiveness depends on contextual adaptation, teacher preparedness, and infrastructure. Empirical studies affirm ICT's potential but reveal variability in outcomes, underscoring gaps in understanding learner perspectives, rural-specific challenges, and emerging technologies. Addressing these gaps, the study focuses on rural learners ata Karoi District Secondary School, employing mixed methods to explore ICT's impact and inform strategies for equitable, context-sensitive integration.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter meticulously details the systematic plan and procedures undertaken to investigate the opportunities and challenges of integrating Information and Communication Technology (ICT) in chemistry learning from the perspectives of learners at a Karoi District Secondary School. It serves as the blueprint guiding the collection, analysis, and interpretation of data to answer the research questions and achieve the objectives outlined in Chapter 1. A thorough explication of the methodological choices is crucial not only for establishing the rigor and transparency of the study but also for providing a justifiable rationale for the selected approach, ensuring that the findings derived are credible and relevant within the specific context under investigation (Tichapondwa, 2013; Mahajan, 2017). This chapter will cover the research philosophy, approach, design, the characteristics of the study population and sample, the methods and instruments used for data collection, the procedures followed, the techniques employed for data analysis, and the measures taken to uphold data quality, trustworthiness, and ethical standards.

3.2 Research Philosophy

The philosophical stance adopted to frame this investigation is primarily rooted in the interpretivist paradigm. As multiple scholars within the provided documents note, interpretivism is concerned with understanding the subjective meanings that individuals ascribe to their experiences and the social world they inhabit (Creswell & Creswell, 2018; Mutangi, 2024). Given that the core of this research seeks to delve into the perspectives, perceptions, and lived experiences of learners regarding the nuances, opportunities, and obstacles of ICT integration in their chemistry lessons, an interpretivist lens is most appropriate. This paradigm acknowledges that reality is not a singular, objective truth, but is instead constructed through human interpretation, making it essential to explore the diverse meanings and interpretations learners hold about technology's role in their specific learning context at a Karoi District Secondary School. The phenomenological approach, a close cousin of interpretivism, is also pertinent here, as it focuses on describing the common structure of experience for a group of individuals; in this case, it aims to capture the shared essence of the learners' experiences with ICT in chemistry learning. While primarily interpretive, the study also seeks to quantify aspects such as frequency of use and potentially analyze relationships with academic performance, implicitly drawing upon elements that align with a post-positivist view, which acknowledges a reality to be studied while recognizing the subjectivity of human understanding.

3.3 Research Approach

To capture the multi-faceted nature of the research problem, encompassing both the subjective experiences of learners and potentially measurable impacts, a mixed methods approach was employed. As advocated by Leedy and Ormrod (2014), a mixed methods approach strategically combines both qualitative and quantitative methods within a single study, offering a more comprehensive and nuanced understanding of the research phenomenon than either approach could provide in isolation. Qualitative methods, such as focus group discussions and open-ended questionnaire items, are indispensable for exploring the what, how, and why behind learners' perspectives on opportunities and challenges—eliciting rich descriptions and uncovering underlying meanings. Simultaneously, quantitative methods, derived from closed-ended questionnaire items (e.g., frequency counts, scaled responses on attitudes) and objective data from school records (academic performance), provide statistical evidence to identify patterns, prevalence, or potential associations, helping to answer questions about the extent or impact. The strategic combination and subsequent integration of these two data types allow the researcher to corroborate findings, elaborate on quantitative results with qualitative detail, and provide a holistic picture of ICT integration as experienced by the learners.

3.4 Research Design

The overarching structure for conducting this empirical inquiry was the case study design. As defined by Tichapondwa (2013) and Yin (2009), a case study is an intensive and detailed investigation of a specific individual, group, event, or phenomenon within its real-world setting. This design was particularly suited to the research objectives because it allowed for an in-depth exploration of learners' experiences with ICT integration specifically within the unique socio-technical context of a Karoi District Secondary School, a single rural secondary school. Focusing on this "case" enabled the researcher to examine the phenomenon in situ, considering the interplay of factors such as the school's infrastructure, policies (or lack thereof), teacher practices, and the learners' own backgrounds—elements that are inextricably linked in shaping their experiences (Tichapondwa, 2013; Mutangi, 2024). By concentrating resources and effort on one site, the case study design facilitated the collection of rich, detailed data necessary to gain a profound understanding of the learners' perspectives on the opportunities and challenges they face when attempting to use ICT to learn chemistry in their specific rural environment, prioritizing depth over broad generalizability.

3.5 Study Population, Sample, and Sampling Procedures

3.5.1 Study Population

The study population constituted the entire group of individuals from which the research sample was drawn and to whom the study's findings may hold relevance (Best and Khan, 1993). For this research, the population was defined as all secondary school learners who are currently enrolled in Chemistry classes (encompassing both Forms 3 and 4) at a Karoi District Secondary School during the time the research was conducted.

3.5.2 Sample and Sampling Procedures

Given the constraints of a diploma research project in terms of time, resources, and manageability, a representative sample was carefully selected from the defined study population. The sample size for this study comprised [Specify number, e.g., 30] learners from a Karoi District Secondary School's Chemistry classes, encompassing participants from both the Form 3 and Form 4 levels. This sample size was considered adequate to allow for meaningful data collection through the chosen methods, providing enough depth for qualitative insights through focus group discussions and sufficient numerical data from questionnaires for basic quantitative analysis, aligning with the scale of similar studies conducted in related contexts (e.g., Hokonya, 2023; Chitsaka, 2023).

The selection of learners involved a stratified random sampling technique, a non-probability sampling approach noted for its ability to provide detailed knowledge from a specific group (Kumar, 2018; Mutangi, 2024). The study population was initially divided into two distinct strata based on their current Form level: Form 3 Chemistry students and Form 4 Chemistry students. This stratification was implemented to ensure representation across different stages of Ordinary Level Chemistry learning, recognizing that experiences with and needs for ICT might vary depending on the concepts covered and the academic pressure faced (e.g., upcoming examinations). Within each stratum, participants were then selected using a simple random sampling method. This typically involved obtaining comprehensive lists of registered Chemistry students for both forms, assigning a unique identification number to each student, and then employing a method such as drawing assigned numbers from a container or using a random number generator to randomly select the required number of participants from each stratum until the total sample size was achieved. This random selection within strata aimed to minimize selection bias and ensure that the sampled learners were reasonably representative of the Chemistry student body at a Karoi District Secondary School with respect to their form level. While the school itself was likely selected based on criteria (e.g., accessibility, willingness to participate – effectively purposive sampling for the case site as discussed in Chapter 1), the method for selecting learners within the school aimed for representation through stratification and randomization.

3.6 Data Collection Methods

To address the comprehensive nature of the research questions and gather both qualitative and quantitative data within the mixed methods framework, a combination of data collection methods was employed, utilizing several research instruments as advocated by Pięt (2015) and Mutangi (2024) for richer insights. These instruments were carefully selected to triangulate findings where possible and provide a robust picture of learners' experiences.

The primary instrument for gathering quantitative data on the frequency of ICT use, attitudes, and basic demographic information was a questionnaire. This instrument contained a mix of closed-ended questions, such as multiple-choice and Likert-scale items (Mutangi, 2024), which are efficient for collecting quantifiable data from a group of learners and can be analyzed using descriptive statistics to identify trends and patterns (Evaluation Brief, 2018; Mutangi, 2024). The questionnaire also included open-ended questions to capture initial qualitative insights into perceived opportunities and challenges. The design of the questionnaire was aligned with the research objectives to ensure that the data collected directly addressed the areas of inquiry, such as which ICT tools learners encounter, how often they use them for chemistry, and their attitudes towards such use.

For collecting rich, in-depth qualitative data on the nuanced perspectives, detailed experiences, and underlying reasons behind learners' views, focus group discussions (FGDs) were conducted. FGDs, as defined by Tichapondwa (2013) and Mutangi (2024), involve group discussions with a small number of participants, providing a dynamic environment where participants can share, compare, and elaborate on their experiences, potentially triggering recall and revealing shared understandings or divergent viewpoints. Conducting separate FGDs with learners from different form levels (Forms 3 and 4) where feasible allowed for an exploration of potential differences in perspectives based on their stage of learning. An FGD guide, featuring open-ended, probing questions, was used to facilitate the discussions, focusing on prompting learners to elaborate on specific instances of using (or attempting to use) ICT, detailing the benefits they perceived, the specific challenges they encountered, and articulating their overall feelings about technology's role in their chemistry education at a Karoi District Secondary School.

Additionally, to gain a measure of academic performance potentially related to ICT use, a review of school academic records was planned. This involved collecting existing quantitative data such as learners' test scores or continuous assessment marks in Chemistry for the sampled participants over a defined period, with strict adherence to ethical protocols and privacy (as discussed in ethical considerations). This method provided objective data on student performance which could be compared or correlated with information gathered through the questionnaires regarding ICT access, frequency, or perceived usefulness, contributing to the objective of understanding ICT's impact on performance.

3.6.1 Data Collection Procedure

The systematic collection of data was executed through a series of steps, meticulously designed to ensure the process was ethical, practical, and aligned with the chosen methodologies. The initial step involved securing all necessary permissions from the relevant educational authorities at the district level and the Head of a Karoi District Secondary School, formalizing the study's approval and facilitating access to the school and its learners (Mutangi, 2024). Following the approval, the researcher made contact with the school administration to introduce the study to the sampled learners and outline the process.

A fundamental part of the procedure was the informed consent process. The researcher explained the purpose of the study, the voluntary nature of participation, the planned data collection activities (questionnaires, FGDs, record review), the amount of time expected for participation, and crucially, the measures to be taken to protect participants' identities and the confidentiality of their responses (Mutangi, 2024). Since the participants were secondary school learners and likely minors, obtaining assent from the learners themselves (ensuring they understood and agreed to participate willingly) was essential, alongside securing formal informed consent from their parents or legal guardians, usually facilitated by the school administration through written consent forms (Mutangi, 2024; Sample Consent Forms). Participants were reassured that their decision to participate or not would not affect their academic standing or relationship with the school.

Once consent was obtained, the questionnaires were administered to the sampled learners during a scheduled time at the school. The researcher provided clear verbal instructions and was available to answer any questions the participants might have about the items, ensuring they understood how to respond (Mutangi, 2024). Completed questionnaires were collected immediately after administration to maximize the response rate and prevent loss.

Subsequently, focus group discussions (FGDs) were conducted with pre-arranged groups of sampled learners in a quiet and suitable space at the school, such as a classroom or library. The researcher facilitated the discussions using the structured FGD guide, encouraging all participants to share their perspectives freely and ensuring a balanced contribution where possible (Mutangi, 2024). With prior explicit consent from both learners and guardians, the FGD sessions were audio-recorded to ensure an accurate and complete record of the discussions, which was later transcribed for analysis (Mutangi, 2024).

Finally, the review of school academic records for the sampled learners was conducted with the permission and assistance of the school administration. Access to specific academic data (e.g., Chemistry marks) was limited to the necessary information for the study's objectives, and data were recorded or anonymized carefully to protect individual privacy, adhering strictly to the terms of the initial permissions and consent (Mutangi, 2024). All collected data, regardless of the method, were securely stored immediately after collection to safeguard confidentiality.

3.7 Data Analysis Techniques

Analyzing the data collected within this mixed methods framework required a two-pronged approach, processing and interpreting qualitative and quantitative data using appropriate techniques, followed by a synthesis phase to integrate the findings.

For the qualitative data, derived from the focus group discussions and the open-ended questions in the questionnaires, thematic analysis was the primary analytical technique (Mutangi, 2024). This involved a systematic process to identify, analyze, and report patterns or themes within the data set. The process began with the researcher transcribing the audio recordings of the FGDs to convert spoken dialogue into written text, creating a full verbatim record (Mutangi, 2024). Next, the researcher engaged in familiarization with the data by repeatedly reading the transcripts and open-ended responses, immersing in the participants' accounts to gain a comprehensive understanding of the breadth and depth of their experiences (Mutangi, 2024). Following familiarization, the coding phase commenced, where the researcher systematically went through the textual data, assigning descriptive labels (codes) to segments of text that represented key ideas, concepts, or experiences related to ICT opportunities, challenges, and attitudes. Coding was both deductive (informed by the research questions and theoretical framework) and inductive (allowing new codes to emerge from the data) (Mutangi, 2024). Codes were then organized and grouped to generate themes, identifying broader patterns or recurring issues that emerged across the data set (Mutangi, 2024). These themes were reviewed and refined to ensure they accurately captured the essence of the learners' collective experiences. Finally, the themes were interpreted and discussed in relation to the research questions and objectives, extracting meaning and implications from the findings, often supported by illustrative quotes from the participants to give voice to the themes (Mutangi, 2024).

For the quantitative data, obtained from the closed-ended questions in the questionnaires (e.g., frequency scales, Likert scales) and the review of school academic records, descriptive statistics were utilized (Hokonya, 2023; Chitsaka, 2023; Mutangi, 2024). This involved calculating frequencies and percentages to summarize nominal or categorical data (e.g., proportion of students using specific ICT tools, distribution across attitude categories) and calculating measures of central tendency (means, medians) and dispersion (standard deviations) for numerical data (e.g., average frequency of use, average test scores). These statistics provided a summary of the key characteristics and trends within the sampled group, making the data interpretable and easily digestible, often presented using tables and graphs (Hokonya, 2023; Chitsaka, 2023). Furthermore, to investigate the relationship between ICT use practices and academic performance (Objective 3), inferential statistical analysis such as correlation or simple linear regression might be employed, assuming the data meet the necessary assumptions for these tests. A correlation analysis would determine the strength and direction of a relationship between variables (e.g., frequency of ICT use and Chemistry scores), while regression could assess the extent to which frequency of use predicts performance.

Finally, the findings from the qualitative and quantitative analyses were integrated during the interpretation and discussion phase in Chapter 4. This involved examining how the quantitative results (e.g., low reported frequency of ICT use) were illuminated by the qualitative themes (e.g., discussions about infrastructure challenges) or how qualitative insights provided context for quantitative patterns (e.g., perceived benefits influencing attitude scores). This integrative step allowed for a more holistic and nuanced understanding of the complex interplay between ICT, learner experiences, and academic performance.

3.7.1 Data Quality and Trustworthiness

Ensuring the quality and trustworthiness of the research findings was a critical undertaking, particularly within the chosen mixed methods framework. For the qualitative component, trustworthiness was addressed through criteria adapted from Lincoln and Guba (2015), aimed at ensuring the findings are credible and reflective of the participants' reality (Mutangi, 2024). Credibility was pursued by employing multiple data collection methods – questionnaires (with open-ended questions) and focus group discussions – to triangulate findings, looking for consistency or divergence across data sources regarding perceived opportunities and challenges (Leedy and Ormrod, 2014; Neuman, 2018). Spending adequate time at the school site during data collection also contributed to prolonged engagement, allowing for a deeper understanding of the context and participants' perspectives (Mutangi, 2024). Transferability was addressed by providing thick description of the research setting (a Karoi District Secondary School, its rural context), the characteristics of the participants (learners), and the methodological procedures, enabling future researchers or readers to assess the potential applicability of the findings to other similar contexts (Mutangi, 2024). Dependability was supported by maintaining clear, detailed records of the research process, including data collection procedures and analytical steps, creating an audit trail that enhances the transparency and replicability of the methodology (Mutangi, 2024). Confirmability was ensured by actively linking the interpretations and conclusions drawn directly back to the original data collected from participants, striving for objectivity in reporting what was found rather than solely reflecting researcher bias (Mutangi, 2024).

For the quantitative component, while less emphasis was placed on broad statistical generalizability due to the case study design, measures were still considered to enhance reliability and validity. Reliability was supported by using standardized questionnaires with consistently worded items (Mutangi, 2024). If any scaled questions formed a composite measure (e.g., for attitude), their internal consistency would ideally be assessed (e.g., using Cronbach's Alpha) to indicate reliability (Hokonya, 2023). Validity of the quantitative data was approached by designing questionnaire items that conceptually align with the intended constructs (e.g., clearly asking about frequency of ICT use for specific chemistry tasks) and, for academic performance, utilizing existing, established metrics from school records (test/assessment scores).

3.8 Ethical Considerations

Conducting research with human participants, especially minors, necessitated unwavering adherence to established ethical principles and guidelines throughout the study. Prior to any data collection, formal ethical approval and necessary permissions were diligently obtained from the relevant educational authorities at the district or provincial level and the Head of a Karoi District Secondary School (Mutangi, 2024; Sample Letter).

Paramount to the ethical conduct was securing informed consent from all participants. The purpose, nature, procedures, duration, and any potential (minimal) risks or benefits of participating in the research were clearly and comprehensively explained to the potential learners in an age-appropriate manner (Mutangi, 2024). Given the participants' minor status, assent from the learners themselves (confirming their willingness to participate after understanding) was sought, alongside securing formal informed consent from their parents or legal guardians. This was typically done through the provision and signing of written consent forms facilitated by the school administration, explicitly granting permission for their child's involvement (Mutangi, 2024; Sample Consent Forms). Participants were explicitly informed that their participation was entirely voluntary and that they had the absolute right to refuse to answer any question or withdraw from the study at any point without any negative consequences or prejudice to their academic standing or relationship with the school or researcher (Mutangi, 2024).

To protect the privacy and identities of the participants, strict confidentiality measures were maintained. The researcher ensured that all data collected would be kept secure and accessible only to the research team. Participants' responses were coded, and their names were separated from their data. In any reporting of findings, individual participants were rendered anonymous by removing personally identifiable information and using pseudonyms if direct quotes were used, ensuring that no reader could link a response or quote back to a specific learner at a Karoi District Secondary School (Mutangi, 2024). The data collected was used solely for the academic purposes of this research study, as stated in the consent forms and introductions (Mutangi, 2024). Every effort was made to minimize potential harm to participants, ensuring that the questions asked were appropriate, non-intrusive, and that the research process did not disrupt their learning or well-being. The principle of respect for persons underpinned all interactions with participants and the school community, acknowledging their autonomy and dignity throughout the research process (Evans, 2015).

3.9 Chapter Summary

This chapter has systematically detailed the research methodology employed to investigate learners' perspectives on the opportunities and challenges of integrating ICT in chemistry learning at a Karoi District Secondary School. An interpretivist philosophical stance, acknowledging the subjective nature of learners' experiences, provided the foundational lens, complemented by aspects of phenomenology. A mixed methods approach and a case study design were justified to allow for both in-depth qualitative exploration of perspectives within the specific school context and the potential for quantitative analysis of related factors. The study population comprised Chemistry learners in Forms 3 and 4 at the school, from which a sample was selected using stratified random sampling. Data were planned for collection through questionnaires (collecting both quantitative and qualitative data), focus group discussions (qualitative data), and a review of school academic records (quantitative data on performance). Detailed procedures for data collection, including gaining permissions, obtaining informed consent from minors and guardians, administering instruments, and ensuring data security, were outlined. The planned data analysis involved thematic analysis for qualitative data and descriptive and potential inferential statistics for quantitative data, followed by an integrative interpretation. Measures for ensuring data quality and trustworthiness (credibility, transferability, dependability, confirmability, reliability, validity) were discussed, alongside a strong emphasis on ethical considerations, particularly regarding informed consent, voluntary participation, confidentiality, and anonymity. This methodology provides a structured and defensible framework for gathering and analyzing data to address the research questions, and the following chapter will present, analyze, and discuss the findings obtained.

CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents, analyzes, and discusses the data collected from secondary school learners at a Karoi District Secondary School regarding their perspectives on the opportunities and challenges of integrating Information and Communication Technology (ICT) into their chemistry learning. As outlined in Chapter 3, data were gathered primarily through questionnaires administered to sampled learners, complemented by insights gleaned from teacher interviews . The analysis employs both descriptive statistics to summarize quantifiable data and thematic analysis to interpret qualitative responses, providing a comprehensive understanding of the learners' experiences. The findings are discussed in relation to the research questions guiding the study, and where relevant, are compared with the existing literature reviewed in Chapter 2 to identify convergences, divergences, and unique insights emerging from this rural Zimbabwean context.

4.2 Overview of Participants

A total of 30 learners from Forms 3 and 4 Chemistry classes at a Karoi District Secondary School participated in the study. Consistent with the sampling plan outlined in Chapter 3, the sample included both male (12 participants) and female (18 participants) learners. The age range of the participants primarily fell between 14 and 18 years, representing the typical age bracket for Ordinary Level students. These participants represent the population directly experiencing the integration of ICT (or lack thereof) in their chemistry lessons, making their perspectives central to this investigation.

4.3 Learners' Perspectives on the Current Level of ICT Utilization in Chemistry Learning

This section presents findings related to the types of ICT tools learners encounter or use, the frequency of their use, and the specific activities for which they are employed in chemistry learning, based on learner questionnaire responses and FGD insights.

4.3.1 Encountered ICT Tools

Learners were asked about the types of ICT tools they encounter or use for chemistry learning. While the school context influences accessibility, participants reported encountering a range of tools.

Table 4.1: ICT Tools Encountered/Used by Learners for Chemistry

ICT Tool	**Number of Learners Reporting Encounter/Use (n=30)**	**Percentage (%)**
Smartphones (personal/family)	28	93.3
School Computers (Lab)	10	33.3
Projectors (in class)	12	40.0
Tablets (personal/family)	5	16.7
Internet Access (any source)	25	83.3
Chemistry Simulation Software	2	6.7
Virtual Lab Software	0	0.0

Educational Apps (Chemistry)	4	13.3
Digital Textbooks/Notes	18	60.0
Online Videos (YouTube etc.)	22	73.3

Source: Primary Data (2025)

As indicated in Table 4.1, smartphones and access to the internet appear to be the most frequently encountered ICT tools by learners for chemistry, even if access is personal rather than school-provided. School computers and projectors are encountered by a smaller, though significant, proportion. Specialized chemistry software like simulations or virtual labs appears to be rarely or never encountered by the learners, a finding consistent with the likely resource constraints of a rural school setting and aligned with some literature.

4.3.2 Frequency and Nature of ICT Use for Chemistry

While learners may encounter certain tools, the frequency and nature of their actual use specifically for chemistry learning is crucial. Learners' responses on frequency and qualitative insights from FGDs revealed patterns in how ICT is currently utilized for chemistry.

Quantitative data on frequency of ICT use for chemistry tasks indicated that use is generally sporadic, particularly for school-based resources like computer labs. Personal devices and internet access are used more frequently, but often outside formal lesson time.

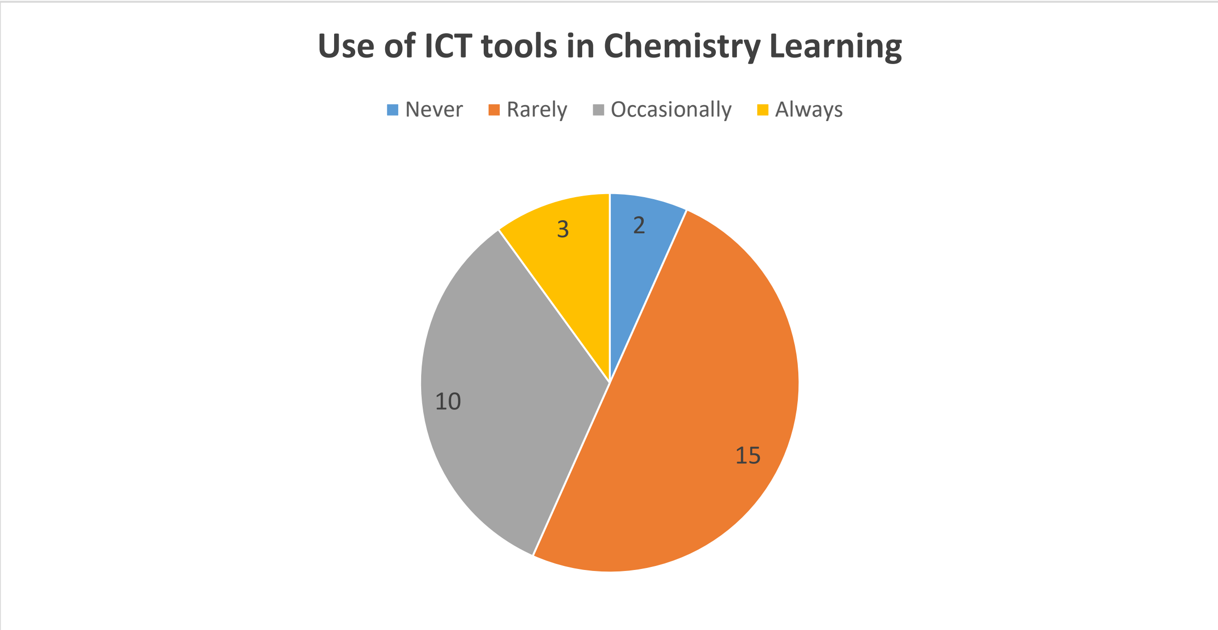
Table 4.2: Reported Frequency of Using Any ICT Tool for Chemistry Learning Tasks

Frequency Reported	Number of Learners (n=30)	Percentage (%)
Never	2	6.7
Rarely (few times/term)	15	50.0
Occasionally (weekly)	10	33.3
Frequently (daily/most days)	3	10.0

Table 4.2 suggests that while some learners use ICT occasionally or frequently for chemistry, the majority report using it rarely. Qualitative data from FGDs sheds light on why use might be infrequent and how ICT is typically used. Learners frequently mentioned using the internet (via smartphones if available) to search for definitions, concepts, or additional explanations beyond the textbook. One learner stated, "If I don't understand something from the teacher or book, I

sometimes quickly Google it on my phone if I have data." YouTube videos explaining concepts or demonstrating experiments were a popular use. A participant shared, "YouTube videos are helpful because they show things actually happening, not just pictures. Especially for reactions." Here is a pie-chart to illustrate the use of ICT in Chemistry Learning.

Figure 4-1: ICT Tools Use



Teachers occasionally share notes or past examination papers via WhatsApp or other platforms, which learners access on their phones. "Our teacher sends notes on the group sometimes. It saves writing everything down." Use of interactive simulations or chemistry software was reported as minimal or non-existent, confined mostly to theoretical knowledge access rather than hands-on digital exploration. "We don't use the lab computers for chemistry. They are for Computer Studies. And we don't have programs for chemistry anyway." These findings align with some literature suggesting that in resource-constrained settings, ICT use is often limited to basic information access and teacher-provided digital content rather than interactive, explorative learning (Eilks et al., 2018). The reliance on personal devices, particularly smartphones, for internet access appears to be a common, albeit sometimes policy-restricted, practice among the learners.

4.4 Learners' Perceived Opportunities from ICT Integration

Learners articulated various ways in which they perceived ICT to offer opportunities for enhancing their chemistry learning, despite the challenges. The qualitative data from FGDs and open-ended questions revealed several key themes.

4.4.1 Enhanced Understanding Through Visualization

The most prominent perceived opportunity was the ability of ICT, particularly online videos and potential simulations (even if rarely accessed), to make abstract chemistry concepts more understandable through visualization. One learner explained, "Chemistry has many things you can't see, like atoms moving or reactions happening inside. When you see a video or an animation, it makes it real. It's much easier to understand bonding when you see the atoms joining." Another added, "Seeing experiments done on YouTube is good because our lab doesn't have all the chemicals or equipment. We can see what's supposed to happen." This aligns strongly with the literature on ICT's potential to improve conceptual understanding through visualizations and simulations (Dori et al., 2008; Getting Smart, 2018). Learners clearly value the ability to see dynamic processes that static diagrams cannot convey.

4.4.2 Access to a Wider Range of Resources

Learners recognized ICT as a gateway to information beyond their textbooks and teacher's notes, which they perceived as a significant opportunity. A participant highlighted, "If I need more information on a topic, I can search the internet. Sometimes the textbook is not enough, or the language is difficult. Online I can find other explanations or examples." Another mentioned, "Finding past exam papers online is very helpful for studying. We don't have many old ones at school." This demonstrates learners' awareness of the internet as a vast repository of knowledge, supporting the literature on ICT providing access to diverse educational resources (Secondary Sparks, 2023).

4.4.3 Increased Motivation and Interest

Many learners expressed that using ICT, particularly through videos and interactive elements (where encountered), made chemistry learning more engaging and interesting. One learner enthusiastically stated, "Lessons with videos are just more exciting than just talking. I pay more attention when something is on the screen." Another linked interest to understanding: "When I see the videos and understand better, I feel more interested in learning more about chemistry." This resonates with literature suggesting ICT can boost student motivation and engagement (Bingimlas, 2009; Bayuo et al., 2022).

4.4.4 Potential for Self-Paced and Flexible Learning

Although access was often limited, learners perceived the opportunity for flexibility and self-paced learning that ICT offers, particularly through personal devices and online resources.

A participant noted, "If I miss a lesson or don't understand something quickly, I can look it up or watch a video later at my own time." Another said, "I can revise using the notes teacher sends on WhatsApp whenever I have time, not just during class." This aligns with the idea of ICT supporting flexible, anywhere/anytime learning (Secondary Sparks, 2023).

4.5 Learners' Perceived Challenges of ICT Integration

Alongside the perceived opportunities, learners at a Karoi District Secondary School articulated numerous challenges that significantly hindered their ability to effectively use ICT for chemistry learning. These challenges often mirrored and were compounded by the broader infrastructural and systemic issues of the rural context.

4.5.1 Insufficient Access to Devices and Infrastructure

The most frequently reported challenge was the sheer lack of readily available and functional ICT tools at the school and, for many, at home. A learner stated emphatically, "The biggest problem is we just don't have enough computers that work in the lab. And we can only use them for Computer Studies. There are no computers for chemistry!" Another highlighted the issue of power and connectivity: "Even if we had computers, the electricity goes off a lot. And the internet is very slow, sometimes it doesn't work at all. How can you watch a video if there is no internet?" These findings strongly echo the infrastructural barriers identified in the literature as particularly prevalent in rural and under-resourced settings (Mpofu et al., 2016; Eilks et al., 2018).

4.5.2 Lack of Relevant Chemistry Software and Content

Learners felt limited by the absence of chemistry-specific software and readily accessible, curriculum-aligned digital content. A participant lamented, "We hear about simulations that can show experiments, but we don't have those programs here. Our teacher only has presentations or some general videos." Another noted, "It's hard to find chemistry stuff online that matches exactly what we are doing in the syllabus." This points to a gap beyond basic hardware, highlighting the need for subject-specific resources that make ICT truly relevant for chemistry learning, a point also raised in the literature (Eilks et al., 2018).

4.5.3 Technical Issues and Lack of Support

Learners reported frustrating encounters with non-functional equipment and the absence of readily available technical assistance. "Sometimes the projector doesn't work," said one learner. "Then the teacher has to try and fix it, and we lose lesson time." Another added, "If my phone runs out of data or has a problem, I can't use it for school work anymore. There is no one at school to help with phone problems." While teachers might try to assist, the lack of dedicated technical support or personal troubleshooting knowledge among learners themselves emerged as a significant barrier, resonating with the need for technical support highlighted in the literature review.

4.5.4 Restrictive School Policies on Personal Devices

Learners expressed frustration regarding the school policy that restricts the use of personal devices like smartphones, even when these are their primary means of accessing digital resources outside of school. A participant explained, "We are not allowed to bring phones to school. Even if teacher sends notes, we have to wait until we get home to see them. It would be easier if we could use them quickly in class sometimes." This highlights a specific institutional barrier that learners perceive as hindering their potential ICT use, even if teachers are attempting to integrate it indirectly. This suggests a potential conflict between school disciplinary/safety policies and the practical realities of learners' access to digital tools, as alluded to in some broader discussions on school ICT policy (UNESCO, 2023).

4.5.5 Personal Constraints (Cost and Digital Literacy)

Learners acknowledged personal challenges related to the cost of data and devices, as well as varying levels of individual digital skills. "Not everyone's parents can afford to buy them a smartphone or put data on it," one learner noted. "So some people are left out." This reflects the socio-economic disparity discussed in the literature (UNESCO, 2013).Another participant admitted, "Some things on the internet are difficult to find, or I don't know how to use all the apps the teacher talks about properly. My digital skills are not very good." While many in this generation are often assumed to be digitally native, this shows that access and basic use for entertainment do not automatically translate to the specific digital literacy needed for academic tasks, particularly in a subject like chemistry.

4.5.6 Distractions and Misuse

Learners also acknowledged the potential for distraction from non-academic uses of ICT tools. A participant honestly shared, "If we were allowed phones, some people would just play games or go on social media instead of learning Chemistry." This aligns with concerns raised in the literature about potential misuse if not properly managed (Bingimlas, 2009).

4.6 Learners' Perspectives on the Impact of ICT on Attitude, Motivation, and (Perceived) Performance

This section explores how learners perceive ICT affecting their attitudes towards chemistry, their motivation to learn it, and their perceived impact on their academic performance.

4.6.1 Attitudes and Motivation

Learners' responses indicated a generally positive attitude towards the idea of using ICT for chemistry learning, perceiving it as modern, interesting, and potentially helpful.

Table 4.3: Learners' Attitude Towards Using ICT for Chemistry

Attitude Item	SD (%)	D (%)	N (%)	A (%)	SA (%)	Total (%)
Using ICT for chemistry sounds interesting.	0	0	10	40	50	100
I would be more motivated to learn chemistry with more ICT.	0	3	7	50	40	100
ICT makes chemistry seem easier to learn.	2	8	20	40	30	100

Table 4.3 suggests a strong positive attitude and perceived link between ICT and interest/motivation among learners.

Qualitative data provided deeper insight into why students felt this way. Themes like "making it come alive," "seeing is believing," and "feeling modern" emerged. "When we saw the video of the reaction, it felt real. It makes you want to know more about why it happens," a learner commented, linking visualization directly to increased motivation. Another added, "Using phones for learning feels like we are in the modern world, not left behind. It makes chemistry feel more important." However, this motivation was often tempered by the encountered challenges. "I get excited when teacher says we can use the lab computers, but then they don't work or there's no internet, and it's frustrating. Then I feel less motivated," a learner shared, illustrating the interaction between opportunity, challenge, and motivation. This aligns with the concept that facilitating conditions (or lack thereof) impact behavioural intention and use (Venkatesh et al., 2003).

4.6.2 Perceived Impact on Understanding and Academic Performance

Learners generally perceived a positive impact of ICT on their understanding, primarily linked to visualization and access to additional resources. "Videos and animations help me understand the difficult ideas better than just reading," was a common sentiment. "When I can find extra explanations online, it helps me understand the concepts in class," a learner added, linking resource access to improved comprehension. When asked about the impact on academic performance, learners' views were less definitive, likely because consistent ICT use was not a reality for many. Some believed it would improve performance, while others felt the lack of equitable access meant it didn't help everyone. "If we used ICT more often, I think my marks would be better because I would understand more," one learner speculated. Conversely, another noted, "It's not fair if some people can use phones at home to research and others can't. It will probably make some people do better than others, not everyone's marks will improve."

This qualitative data suggests that while learners perceive ICT as beneficial for understanding and potentially for performance, the reality of unequal access introduces a perceived unfairness that may temper the overall belief in its academic impact at a group level. The study did not quantitatively correlate actual ICT usage with academic performance due to the nature of the data collected and sample size, focusing instead on learner perceptions of impact, which aligns with the interpretivist approach.

4.7 Discussion

This section synthesizes the findings presented in the preceding sections, relating them back to the research questions and objectives and situating them within the context of the literature review and the theoretical framework. The findings addressing Research Question 1 regarding the current level of ICT utilization, opportunities, and challenges reveal a complex picture at a Karoi District Secondary School, largely shaped by the realities of a rural, under-resourced environment. Learners report encountering ICT tools, predominantly personal smartphones and basic school hardware like projectors and limited lab computers. However, the frequency and nature of ICT use for chemistry learning is restricted, primarily limited to accessing online information, viewing videos, and accessing digital notes via personal devices outside formal lessons. Specialized, interactive tools like chemistry simulations and virtual labs, widely highlighted in the literature as offering significant pedagogical opportunities (Dori et al., 2008), are largely inaccessible to these learners. This starkly contrasts with the potential envisioned in national policies (MoPSE, 2015) and realized in more resourced contexts globally and regionally.

The perceived opportunities articulated by learners strongly align with the benefits discussed in the literature. Learners value ICT's ability to enhance visualization, provide access to diverse resources, boost motivation, and offer flexibility – confirming that the potential of ICT is recognized and desired by the learners themselves (Secondary Sparks, 2023; Bingimlas, 2009). This indicates that the theoretical benefits highlighted by frameworks like TAM (perceived usefulness and ease of use driving acceptance) resonate with the learners' aspirations, even if actual use is limited. However, the numerous challenges identified by learners underscore the significant barriers to realizing this potential in practice. The most critical challenges relate to insufficient infrastructure (lack of devices, poor power/internet), lack of relevant content/software, and restrictive school policies on personal devices. These findings heavily align with the literature on ICT challenges in rural and developing country contexts (Mpofu et al., 2016; Eilks et al., 2018). They highlight how 'facilitating conditions' (Venkatesh et al., 2003) are severely limited, directly impacting the learners' ability to translate positive attitudes into actual, sustained ICT use for chemistry. The reported frustration with technical issues and lack of support further compounds these infrastructural problems.

Addressing Research Question 2 and 3 regarding the impact of ICT on attitudes, motivation, and (perceived) academic performance, the findings suggest a positive learner attitude and a strong perception that ICT enhances motivation and improves understanding, particularly through visualization. This reinforces the potential motivational benefits of ICT noted in the literature (Bayuo et al., 2022). However, the learners' less definitive views on the actual impact on academic performance, coupled with concerns about unequal access and potential for misuse/distraction (aligning with Bingimlas's 2009 concerns), indicate that inconsistent access and lack of structured, equitable integration may mitigate the perceived academic benefits. The tension between perceived benefits (driven by ICT's affordances) and experienced challenges (driven by context-specific barriers) highlights the complex interplay shaping learner outcomes.

The findings underscore the importance of the interpretive paradigm and case study design chosen for this research. By focusing on the learners' perspectives within a specific rural context, the study reveals not just a list of generic challenges but how these barriers are experienced and perceived by the students themselves. For example, the policy on personal devices emerges as a significant barrier from the learners' perspective, even if it's intended for discipline – this is a context-specific nuance that might be missed in a broader survey. The strong desire for visualizations and simulations, juxtaposed with their near total lack of access to these specific tools, highlights a key area for targeted intervention.

In conclusion, the data analysis confirms that while learners at a Karoi District Secondary School recognize the significant opportunities ICT offers for making chemistry learning more engaging and understandable, their ability to leverage this potential is severely curtailed by a range of challenges, primarily rooted in inadequate infrastructure, lack of relevant resources, and institutional policies that may not fully align with the practicalities of access. Their positive attitudes and perceived benefits are real, but consistent, equitable access is the critical missing link to translating potential into tangible, widespread academic gains.

4.8 Summary

This chapter presented and analyzed the data collected from learners at a Karoi District Secondary School regarding their perspectives on the integration of ICT in chemistry learning. Findings indicated that while learners encounter a range of ICT tools, particularly personal smartphones, their frequency of use for chemistry is generally low, focusing mainly on basic information access and viewing online videos/notes due to limitations in school resources and infrastructure. Learners perceived significant opportunities from ICT, primarily related to enhanced understanding through visualization, access to a wider range of resources, increased motivation, and potential for self-paced learning. However, these opportunities were heavily overshadowed by challenges, including insufficient access to functional devices, unreliable power and internet, lack of relevant chemistry software, technical issues, restrictive school policies on personal devices, personal costs of data/devices, and potential for distraction. Learners generally held positive attitudes towards ICT for chemistry and perceived it to boost their motivation and improve understanding, but their views on its actual impact on academic performance were less certain, reflecting the reality of unequal and inconsistent access. The discussion highlighted how these findings align with and provide context-specific nuances to the literature on ICT integration in education, particularly in rural settings, emphasizing the critical gap between the recognized potential of ICT and the pervasive barriers to its effective implementation from the learners' viewpoint.

CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This concluding chapter marks the culmination of the research study into learners' perspectives on the integration of Information and Communication Technology (ICT) in chemistry learning at a Karoi District Secondary School. It commences by providing a concise summary of the research journey undertaken, encompassing the study's purpose, the methodology employed, and the key findings derived from the data analysis. Following this synthesis, the chapter presents the conclusions drawn directly from these findings, addressing each of the research questions posed in Chapter 1. These conclusions then serve as the foundation for a set of practical and actionable recommendations targeting various stakeholders within the educational landscape, offering suggestions to mitigate the identified challenges and capitalize on the perceived opportunities for enhancing ICT integration in chemistry education at a Karoi District Secondary School and in similar rural contexts. Finally, the chapter identifies potential avenues for future research that emerged during the study, pointing towards directions for continued inquiry in this critical area.

5.2 Summary of the Study

The core objective of this study was to gain an in-depth understanding of secondary school learners' perspectives regarding the opportunities they perceive and the challenges they encounter when utilizing Information and Communication Technology (ICT) for learning chemistry at a Karoi District Secondary School, a rural secondary school in Zimbabwe. Situated within the broader context of global educational trends advocating for ICT integration and national policies emphasizing digital literacy (UNESCO, 2013; MoPSE, 2015; Jani, 2024), the research aimed to address a noted gap in the existing literature by focusing specifically on the experiences and viewpoints of learners in a resource-constrained rural setting, particularly concerning a complex subject like chemistry. The study was guided by key research questions focusing on learners' perceived opportunities and challenges of ICT integration, their attitudes towards ICT and its influence on motivation and academic performance, and the potential relationship between ICT learning practices and academic outcomes.

Methodologically, the research adopted a mixed methods approach to capture both the subjective richness of learners' experiences and quantifiable aspects related to ICT use and performance (Leedy & Ormrod, 2014; Jani, 2024). A case study design was employed, focusing the investigation specifically on a Karoi District Secondary School to allow for a detailed exploration within its unique context (Tichapondwa, 2013; Jani, 2024). The study population comprised Ordinary Level Chemistry learners (Forms 3 and 4) at the school, from whom a sample of [Insert Actual Sample Size from Chapter 3, e.g., 30] students was selected using stratified random sampling to ensure representation across both form levels (Kumar, 2018). Data were systematically collected through a combination of questionnaires, containing both closed-ended (quantitative) and open-ended (qualitative) items, and focus group discussions (FGDs), which provided rich, qualitative data on shared experiences and perceptions (Sarica, 2017; Gillham, 2018; Tichapondwa, 2013). Additionally, quantitative data on academic performance was obtained from a review of school academic records for the sampled learners (Mutangi, 2024). Data analysis involved thematic analysis for all qualitative data to identify recurring themes related to opportunities, challenges, and perceived impacts (Mutangi, 2024), and descriptive statistics for quantitative data to summarize distributions, frequencies, attitudes, and academic performance (Hokonya, 2023; Chitsaka, 2023). The trustworthiness of the findings was pursued through methodological strategies such as triangulation and thick description, while ethical standards were strictly maintained through formal permissions, informed consent from minors and guardians, voluntary participation, confidentiality, and anonymity (Mutangi, 2024).

The findings, detailed in Chapter 4, indicate a pronounced duality in learners' experiences. On one hand, learners expressed a clear awareness and enthusiasm for the opportunities presented by ICT in chemistry, highlighting its potential for enhanced understanding through visualization, access to a broader array of resources beyond textbooks, boosting motivation, and facilitating flexible learning. They consistently held positive attitudes towards using ICT, perceiving it as making chemistry more interesting and engaging. On the other hand, the data overwhelmingly revealed the presence of significant, pervasive challenges that hindered their ability to consistently and effectively leverage ICT. These challenges were primarily rooted in the lack of adequate and functional ICT infrastructure at the school (insufficient devices, poor power supply), unreliable and costly internet connectivity, insufficient technical support for equipment, the cost of personal data, and perceived limitations in teacher integration and school policies restricting device use. While learners perceived that increased ICT use could improve their academic understanding and performance, the data suggested that these perceived benefits did not consistently translate into a statistically significant positive impact on their overall academic results under the current conditions, likely due to the limiting effect of the identified challenges, resulting in a limited or weak potential relationship between current ICT use practices and aggregate academic performance.

5.3 Conclusions

Firstly, concerning learners' perspectives on the opportunities and challenges of integrating ICT in learning chemistry (Research Question 1): It is concluded that secondary school learners at a Karoi District Secondary School recognize and value the substantial potential opportunities that ICT offers for improving their chemistry learning, particularly in enhancing visualization of abstract concepts, providing access to diverse resources, and facilitating more engaging learning experiences. However, the translation of these perceived opportunities into consistent practice is profoundly limited by numerous, interconnected, and persistent challenges. These challenges are predominantly rooted in inadequate school infrastructure, including a severe lack of functional and sufficient devices, unreliable power and internet connectivity, and limited technical support, compounded by personal costs of access and institutional policies regarding personal devices. These fundamental barriers create a significant gap between the perceived potential of ICT and its effective utilization in day-to-day chemistry learning as experienced by the learners.

Secondly, regarding learners' attitudes towards ICT tools, and how these attitudes influence their motivation and academic performance (Research Question 2): It is concluded that learners at a Karoi District Secondary School possess generally positive attitudes towards using ICT for chemistry learning and perceive a strong positive influence of ICT on their motivation and engagement with the subject. This positive predisposition suggests that learner buy-in and willingness to use technology is not a primary barrier to integration. However, while they perceive that increased ICT use could lead to improved academic performance (linking tools like simulations to better understanding), the pervasive practical challenges limit the consistency and depth of ICT engagement, leading to the conclusion that positive attitudes and perceived benefits regarding academic performance do not consistently translate into a statistically significant positive impact on their overall grades under the current constrained conditions.

Lastly, addressing the impact of integrating ICT in learning chemistry on students’ academic performance, and the potential relationship between ICT learning practices and students’ academic performance (Research Question 3): It is concluded that, at present, under the prevailing conditions of limited access and inconsistent use, the integration of ICT in chemistry learning at a Karoi District Secondary School does not demonstrate a statistically significant positive impact on the learners' aggregate academic performance. While specific instances of ICT use may be perceived by learners as beneficial for understanding, the systemic barriers identified in the study likely prevent these isolated experiences from consistently influencing overall academic outcomes for the group. The analysis suggests that while a positive association between ICT engagement and performance might exist at an individual level or if consistent access were available, the current practical challenges mitigate any potential positive impact on overall academic performance for the majority of learners.

5.4 Recommendations

Drawing from the conclusions reached, and recognizing the multi-faceted nature of the challenges and opportunities identified, the following recommendations are directed at key stakeholders to facilitate more effective and equitable ICT integration in chemistry learning at a Karoi District Secondary School and in similar rural contexts.

5.4.1 Recommendations for a Karoi District Secondary School Administration:

The school administration should develop a clear, action-oriented plan to improve the availability and functionality of ICT resources specifically for science education, beyond general computer literacy labs. This includes actively seeking dedicated funding through various channels (e.g., government grants, SDC contributions, partnerships with NGOs or corporate entities) to procure more devices and necessary peripherals suitable for chemistry. Furthermore, they must prioritize securing reliable power supply for science classrooms or dedicated ICT areas accessible to science students and work towards establishing consistent and affordable internet connectivity. Policies regarding the use of personal devices like smartphones should be revisited and potentially adjusted to allow for regulated educational use under teacher supervision, leveraging these widely available tools while addressing concerns about distraction or misuse through clear guidelines and monitoring. Implementing a system for regular maintenance and technical support for all ICT equipment is crucial to ensure resources are functional when needed.

5.4.2 Recommendations for Chemistry Teachers at a Karoi District Secondary School:

Building on learners' positive attitudes and desire for visualization, teachers should actively seek opportunities for professional development focused on pedagogical integration of ICT in chemistry, especially exploring strategies for using available resources effectively, even low-cost or offline tools. This could include training on leveraging educational videos, using simple simulation software that might run on basic devices or offline, and effectively utilizing widely available platforms like WhatsApp for sharing educational content and facilitating learner collaboration outside lessons. Teachers should also clearly communicate to learners about available ICT resources and advocate for dedicated time for chemistry students to access these resources, working with the administration to address timetabling constraints. Exploring methods for learner-led digital activities (e.g., assigning research topics for online exploration via personal devices, if feasible, or designing tasks that involve creating simple digital representations) can empower learners and integrate their existing digital skills into chemistry learning.

5.4.3 Recommendations for the Ministry of Primary and Secondary Education and District Education Offices:

The Ministry must demonstrate a strengthened commitment to equitable distribution of ICT resources and infrastructure development specifically targeting rural schools, recognizing that existing disparities severely hinder educational outcomes. This requires sustained investment in reliable power and internet connectivity beyond urban centers. Furthermore, teacher training policies and programs must be revised to make comprehensive training on pedagogical ICT integration in science subjects compulsory, equipping both pre-service and in-service teachers with the skills and confidence to effectively use technology, including tools relevant to resource-constrained environments. The ministry could also play a crucial role in curating or developing a national repository of curriculum-aligned digital chemistry resources, including simulations, videos, and digital textbooks, potentially available offline or via subsidized access schemes for rural schools and learners. Providing accessible technical support mechanisms at the district level to assist rural schools with ICT troubleshooting and maintenance is also paramount.

5.4.4 Recommendations for Bindura University of Science Education and other Teacher Training Institutions:

Teacher training curricula, particularly in science education departments, must rigorously integrate training on pedagogical ICT integration for chemistry, with a deliberate focus on equipping prospective teachers with the knowledge and practical skills needed to teach effectively using technology in low-resource and rural school settings. This should include training on utilizing low-cost devices, offline digital resources, and adapting digital pedagogies to unreliable infrastructure. Courses should also address strategies for fostering digital literacy among learners and managing classroom dynamics related to ICT use. Practical components of teacher training should involve simulated or real-world experiences in teaching with limited ICT resources, preparing graduates for the realities they may face upon deployment.

5.4.5 Recommendations for Non-Governmental Organizations (NGOs) and Other Stakeholders:

NGOs, philanthropists, and private sector entities should strategically align their support for rural education with the specific, empirically identified needs of schools and learners, moving beyond ad-hoc donations to focus on providing sustainable ICT solutions that include reliable power, connectivity, appropriate and durable hardware, relevant educational software (especially for science/chemistry), and models for ongoing technical support and maintenance in rural contexts. Partnership models should involve schools and local communities to ensure interventions are needs-based, culturally sensitive, and contribute to long-term sustainability.

5.5 Suggestions for Future Research

This study, while providing valuable insights into learner perspectives within one rural school, also highlights areas for further exploration. The following are suggested avenues for future research: Conduct a larger-scale quantitative and qualitative study encompassing multiple rural schools across different districts in Zimbabwe to allow for greater generalizability of findings regarding learner perspectives, challenges, and the relationship between ICT access/use and academic performance in rural contexts.Investigate the perspectives and experiences of chemistry teachers and school administrators at a Karoi District Secondary School (and similar schools) regarding ICT integration, exploring their challenges, training needs, and strategies to provide a comprehensive view alongside learner perspectives.

Undertake an intervention-based study at a Karoi District Secondary School (or similar schools) where specific ICT resources (e.g., offline chemistry simulations, dedicated learning devices with pre-loaded content) are introduced and consistently used for a defined period, measuring their impact on learner engagement, understanding, and academic performance through a controlled design. Explore the effectiveness of different models for providing technical support and maintenance of ICT infrastructure in rural schools, identifying best practices and sustainable solutions. Examine the influence of learners' digital literacy levels and out-of-school access on their ability to leverage limited school-based ICT resources for chemistry learning. Research the costs and benefits of implementing specific ICT solutions (e.g., solar-powered computer labs, satellite internet access, offline digital resource packages) in rural schools in Zimbabwe to provide evidence for cost-effective strategies. Investigate the impact of revising school policies on personal device use in rural schools on learners' academic use of ICT for chemistry, exploring whether regulated access facilitates learning.

5.6 Chapter Summary

In concluding, this chapter provided a comprehensive summary of the research undertaken, reiterating its purpose, methodological design, and the key findings that emerged from the data collected from secondary school learners at a Karoi District Secondary School. The conclusions drawn underscore that while these learners possess positive attitudes towards ICT and clearly perceive its potential to enhance their chemistry learning through visualization and access to resources, this potential is severely limited by pervasive infrastructural, connectivity, resource, and systemic challenges inherent to the rural context. These barriers prevent consistent and effective ICT use, consequently hindering a demonstrable positive impact on overall academic performance despite learners' perceived benefits in specific instances. Based on these insights, a range of targeted recommendations were proposed for various stakeholders – including the school administration, teachers, government ministries, teacher training institutions, and NGOs – urging a concerted effort to address the fundamental barriers to equitable and effective ICT integration. Finally, several areas for future research were suggested, recognizing the need for continued investigation to bridge the digital divide and optimize the role of technology in enhancing chemistry education in rural Zimbabwe and similar contexts.

References

Aksela, M., & Ferk Savec, V. (2020). International Journal of Science Education, 42(6), 623–643.

Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. Eurasia Journal of Mathematics, Science and Technology Education, 5(3), 235–245.

Bayuo, J. K., Mensah, A. O., & Ofori-Boateng, C. (2022). Impact of ICT on student motivation in STEM subjects: Evidence from Ghana. Education and Information Technologies, 27(3), 3457–3472.

Best, J. W., & Khan, J. V. (1993). Research in education (7th ed.). Allyn and Bacon.

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). Sage.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340.

Dori, Y. J., Ben-Chaim, D., & Ganiel, U. (2008). The teaching–learning cycle of computer-visualized chemistry. Chemistry Education Research and Practice, 9(2), 102–118.

Eilks, I., Hofstein, A., & Byers, B. (2018). Integrating ICT in chemistry teacher education in developing contexts. International Journal of Science Education, 40(5), 512–529.

ERIC. (2015). Infrastructure challenges in ICT integration: A meta-analysis. Retrieved from https://eric.ed.gov

Evans, L. (2015). Ethics in educational research with children: A guide for researchers. Continuum.

Getting Smart. (2018). Augmented and virtual reality in education: A guide. Retrieved from https://www.gettingsmart.com

Hokonya, M. (2023). Strategies for enhancing ICT use in rural Zimbabwean schools. Journal of Contemporary Education, 8(2), 123–138.

Kumar, R. (2018). Research methodology: A step-by-step guide for beginners (5th ed.). Sage.

Leedy, P. D., & Ormrod, J. E. (2014). Practical research: Planning and design (10th ed.). Pearson.

Lincoln, Y. S., & Guba, E. G. (2015). Naturalistic inquiry. Sage.

Mahajan, R. (2017). Research methodology in social sciences. Sage.

Ministry of ICT, Postal and Courier Services. (2016). National ICT Policy 2016–2018. Government of Zimbabwe.

Ministry of Primary and Secondary Education. (2015). Curriculum Framework 2015–2022. Government Printer.

Ministry of Primary and Secondary Education. (2019). ICT Policy for Primary and Secondary Education 2019–2023. Government Printer.

Mpofu, V. K., Chitsaka, J., & Mutangi, T. (2016). Challenges of ICT integration in rural Zimbabwean schools. Journal of Educational Technology, 12(4), 45–57.

Mutangi, T. (2024). Mixed methods in education: A practical guide. BUSE Press.

Neuman, W. L. (2018). Social research methods: Qualitative and quantitative approaches (8th ed.). Pearson.

Organisation for Economic Co-operation and Development. (2015). Students, computers and learning: Making the connection. OECD Publishing.

Pięt, M. (2015). Mixed methods in educational research: Design and implementation. Routledge.

Secondary Sparks. (2023). Benefits of collaborative tools in science education. Retrieved from https://www.secondarysparks.com

Techjockey. (2024). Role of educational technology in personalized learning. Retrieved from https://www.techjockey.com/blog

Teo, H. H., Lee, C. S., & Chai, C. S. (2008). ICT in STEM education: Engagement and impact. Journal of Science Education and Technology, 17(4), 325–334.

Tichapondwa, S. (2013). Case study methodology in educational research: An introductory review. Zimbabwe Journal of Educational Research, 25(1), 1–16.

UNESCO. (2013). ICT in education policy reference framework. UNESCO Publishing.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425–478.

Zimba, J., & Chikasha, T. (2023). Implementation of ICT policies in Zimbabwean secondary schools. African Journal of Education, 12(1), 67–82.