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of Science Education



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TITLE

**INTERGRATION OF ICT TOOLS IN TEACHING AND LEARNING OF PHYSICS
IN RESOURCE-CONSTRAINED SCHOOLS**

BY

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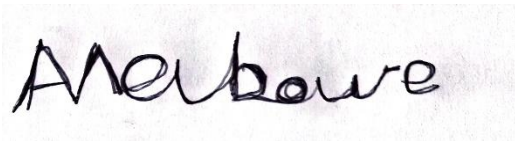
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A research project submitted to Bindura University of Science Education in partial fulfillment of the requirements of the Bachelor of Science Education Honours Degree in Physics.

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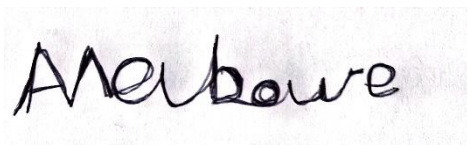
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DEDICATION

This project is dedicated to my loving husband, Marshall Makaure, and our children. Your love, encouragement and understanding have been my greatest source of strength and inspiration throughout this journey.

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to my supervisor, Dr. Zezekwa, for his invaluable guidance, encouragement, and constructive feedback throughout this research. His mentorship and support made this study possible. My sincere appreciation also goes to my Headmaster, Mr. Chafesuka, for granting me permission and support to conduct this study at the school. Special thanks go to Ms. Nengomasha, whose assistance, motivation, and words of encouragement were instrumental during the research process. Finally, I extend my heartfelt appreciation to all the teachers and learners who participated in the study. Their cooperation and honest responses contributed greatly to the success of this research.

ABSTRACT

The study examined the Integration of Information and Communication Technology (ICT) tools in the teaching and learning of Physics in resource-constrained secondary schools Zvimba District. The main objectives were to determine the availability and accessibility of ICT tools, evaluate their effectiveness in supplementing the shortage of laboratories and apparatus, identify challenges faced by teachers and learners, and propose strategies to enhance ICT adoption. A mixed-methods approach was used, combining questionnaires, interviews, and classroom observations to collect both quantitative and qualitative data. Findings revealed that educational videos and simulations were the most commonly used ICT tools in Physics lessons. However, their use was hindered by challenges such as unreliable electricity, shortage of computers, and poor internet connectivity. Despite these limitations, both teachers and learners demonstrated positive attitudes towards ICT integration, acknowledging its role in improving understanding of abstract Physics concepts and increasing learner engagement. The study concluded that ICT tools have great potential to enhance Physics learning in schools with limited resources if infrastructural, technical, and professional support systems are strengthened. It recommended the use of solar power backups, increased ICT resources, and continuous teacher training to promote effective and sustainable ICT integration in Physics education.

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1.0 CHAPTER ONE: INTRODUCTION

1.1 Introduction

This chapter introduces the study on using information and communication technology (ICT) tools to improve teaching and learning physics in secondary schools with limited resources. The chapter begins by presenting the background of the study, which highlights the challenges faced by schools that teach Physics without adequate resources such as laboratories, apparatus, and textbooks. The chapter further explains the rationale for integrating Information and Communication Technology (ICT) tools as an alternative way of enhancing the teaching and learning of Physics in such contexts. In addition, the chapter states the purpose of the study, the research objectives, and the research questions that guide the investigation. It also discusses the assumptions underlying the study, as well as its significance, delimitations, and limitations. Key terms used throughout the research are clearly defined to ensure consistency and understanding. Overall, this chapter provides an overview of the study and sets the groundwork for exploring how ICT tools such as simulations, virtual laboratories, and multimedia resources can be effectively integrated to improve the teaching and learning of Physics in resource-constrained secondary schools.

1.2 Background of the Study

Physics is recognized as one of the core sciences that opens pathways into engineering, medicine, technology, and other science-related professions. It does not only prepare learners for examinations but also develops the ability to think critically, solve problems, and apply knowledge to real-world challenges. Despite its importance in driving innovation and national development, Physics remains one of the most challenging subjects to teach and learn, especially in resource-constrained schools.

In Zimbabwe, the Ministry of Primary and Secondary Education (MoPSE) has highlighted the importance of science education through policies such as Education 5.0, which emphasizes innovation, research, and community engagement (Chikasha et al., 2020). However, despite these policies many schools continue to struggle in teaching Physics. Learning Physics requires more than memorising formulas and definitions. To fully understand concepts such as motion, electricity and magnetism, or waves, learners need opportunities to conduct experiments, make

observations, and test scientific principles practically. Lack of laboratories, inadequate apparatus, and the shortage of new curriculum textbooks have created an uneven learning environment between most urban schools with resources and resource-constrained schools (Mlambo, 2019). It is in this context that the integration of Information and Communication Technology (ICT) tools emerges not as a luxury, but as a possible support system for Physics education in under-resourced schools.

ICT tools offer alternative ways for delivering Physics concepts through the use of virtual labs, simulations, animations, and interactive multimedia resources that can be used for experiments. Software such as PhET Interactive Simulations and other virtual lab platforms can simulate experiments in optics, kinematics, thermodynamics, and electricity, giving students a visual and interactive way to explore scientific principles (Perkins et al., 2006). These ICT tools do not replace the need for physical experiments completely, but can help in situations where there are no laboratories and apparatus by providing an effective alternative. Mobile phone ownership has increased in Zimbabwe, and more young people are now able to access online learning resources. Learners can now become active participants instead of passive recipients, which can help them gain knowledge and develop problem-solving skills. Maroni (2020) states that teachers with laptops and projectors can bring demonstrations into classrooms without laboratories, showing experiments through videos or software applications.

However, in some cases devices are available but are underutilized because some teachers are not confident enough to use them for teaching Physics. The integration of ICT is not without its challenges. Power cuts, poor internet connectivity, and lack of training for teachers often limit what schools can do with the technology they have (Chinyoka & Naidu, 2013). Despite all this, in schools where teachers and learners have been able to make use of ICT, the results have been encouraging. Studies in different situations show that learners exposed to ICT tools perform better and are more motivated than those relying only on textbooks and lectures (Yusuf & Balogun, 2020).

The integration of ICT corresponds with modern educational theories that recommend active, learner centred education. According to constructivist theories, learners build new knowledge more effectively when they are actively engaged with the content, especially through experimentation and discovery (Piaget, 1954; Vygotsky, 1978). ICT tools provide these

opportunities by allowing students to explore variables, test hypotheses, and get immediate feedback that is missing in traditional lecture methods being used to teach Physics in resource-constrained settings. Emerging studies indicate that ICT integration in teaching can significantly improve student understanding of difficult Physics concepts, increase engagement, and improve academic performance. For example, studies have shown that students who learn through simulations and visualizations perform better in tests of conceptual understanding than those who receive lectures only. Teachers also benefit, as ICT tools can serve as teaching aids that make difficult topics easier to explain and demonstrate.

In most parts of the country, Physics continues to record low pass rates among science subjects, especially in public secondary schools located in under-resourced areas. The main reason for this is the lack of access to teaching aids that make the subject clearer. Concepts such as projectile motion, electromagnetic waves, and energy conservation are difficult for students to grasp without visual or experimental support. Yet in most rural schools and peri-urban schools, learners find these concepts only in textbooks if the textbooks are available at all (Dhlamini, 2016). This has greatly contributed to poor performances in the ZIMSEC examinations, with many learners considering Physics as a very difficult subject.

In essence, the integration of ICT in Physics teaching is not just a technical intervention; it is a human-centred solution. It recognizes that learners, regardless of where they live or the resources available, deserve access to quality education. This study is therefore seeking to explore how ICT tools can be effectively integrated to ensure that learners without resources such as laboratories, apparatus, equipment, and enough textbooks still acquire quality education and practical exposure to Physics as a subject.

1.3 Statement of the Problem

Physics is recognised as a science subject that plays a crucial role in technological innovation, national development, and scientific literacy. It educates learners to think critically, analyse problems logically, and apply concepts to real-world situations. Despite the subject's critical role in science and technology education, learners in resource-constrained schools continue to perform poorly in national examinations (Mhlanga and Chivore, 2019). Important resources such as functional science laboratories, new curriculum Physics textbooks, and standard experimental

apparatus are missing in some schools. These shortages create key challenges to quality science education.

In classrooms where these resources are unavailable, the teaching of Physics is reduced to just lectures and chalkboard explanations. Teachers often rely on describing verbally and using improvised diagrams to explain experimental concepts such as electric circuits, wave behaviour, or laws of motion. Unfortunately, these types of teaching methods leave many students struggling to understand and apply what they are being taught. This has led to Physics becoming a source of anxiety and confusion rather than curiosity and excitement. This therefore leads to low academic performance, poor examination results, and a growing disinterest in science-related careers among students in these underserved regions (WAEC, 2021; Umeh and Ogbeba, 2022). Low academic performance in Physics limits learners' ability to pursue careers in science, engineering, and technology fields. This limitation also restricts the nation's potential growth and development. Zimbabwe needs a scientifically literate population to drive innovation and economic growth (World Bank, 2020). While ICT has been shown to transform learning in urban and well-resourced schools, its impact in rural, resource-constrained schools remains underexplored (UNESCO, 2021). Physics teachers are not to blame as they often put a lot of effort to deliver lessons in difficult conditions. But without the necessary tools to support inquiry-based and practical learning, even the most committed teachers are limited in what they can achieve. Some schools have no Physics textbooks at all and others have out-dated curriculum materials which are passed from generation to generation without being updated. Students are left to memorise formulas without ever seeing how they work in real life.

There is a gap in current research concerning how ICT tools can be successfully implemented in Physics education when materials like textbooks, labs, and apparatus are completely absent. It is against this framework that this study seeks to explore the integration of ICT tools in teaching Physics in schools that do not have sufficient resources. This research aims to uncover the practical realities of ICT use in such contexts, examine its effects on student engagement and understanding and propose realistic strategies to support teachers in using ICT as an alternative teaching tool.

1.4 Research Questions

This study is guided by the following research questions:

1. Which ICT tools are currently available and accessible to teachers and learners for the teaching of Physics in resource-constrained schools?
2. How can ICT tools be effectively integrated to supplement the shortage of laboratories, apparatus, and textbooks in Physics teaching?
3. What challenges do teachers and learners face in the integration of ICT in Physics education in resource-constrained schools?
4. What strategies can be used to enhance the effective adoption and utilization of ICT tools in Physics teaching and learning?

1.5 Research objectives

The objectives of this study are to:

1. Identify and describe the difficulties teachers and learners face in schools without proper laboratories, textbooks and science equipment.
2. Evaluate the effectiveness of ICT tools in improving student engagement, understanding and performance in Physics.
3. How ICT tools such as simulations, virtual labs, and educational videos can be used to teach physics in resource constrained schools.
4. Suggest practical strategies that the school can use to support the use of ICT tools in physics education, especially in resource constrained schools.

1.6 Purpose of the Study

The purpose of this study is to examine how Information and Communication Technology (ICT) tools can be effectively integrated into the teaching of Physics in schools that lack basic educational resources such as laboratories, textbooks, and scientific apparatus. Umeh and Ogbeba (2022) state that in many under-resourced schools, particularly in rural and economically disadvantaged areas, Physics education is reduced to abstract theoretical explanations that often fail to engage students or develop meaningful conceptual understanding. This study seeks to

investigate whether using ICT tools such as virtual laboratories, simulations, animations and mobile phones can improve teaching Physics in schools which are resource-constrained.

The study also seeks to determine the extent to which ICT tools can simulate the functions of physical laboratories and instructional materials in the absence of traditional teaching aids. Specifically, the study will assess the impact of ICT-based instruction on students' comprehension of Physics concepts, engagement levels, and academic performance. As earlier studies have shown, tools like PhET Interactive Simulations and other open-source platforms offer interactive and visually rich learning experiences that can significantly aid in conceptual understanding (Perkins et al., 2006; Wieman and Perkins, 2015). As such, by focusing on these alternatives, the study aims to provide practical strategies that can help resource-constrained schools to improve the quality of Physics education without using high infrastructural costs.

Research conducted by Morrison et al. (2017) emphasized the importance of incorporating ICT in Physics education to bridge the gap between abstract concepts and real-world applications. The findings revealed that the use of ICT tools increased student participation and fostered a collaborative learning environment. As such, by utilising ICT tools, teachers can access a wide range of resources, adapt instructional materials to meet individual students' needs and provide timely feedback to enhance the learning process

1.7 Assumptions of the Study

The study is based on the following assumptions:

- Teachers and learners in resource-constrained schools have at least minimal access to ICT devices such as smartphones, laptops, or projectors.
- ICT tools such as simulations and virtual laboratories can effectively supplement traditional teaching methods in Physics.
- Teachers are willing to integrate ICT into their teaching practices if given adequate training and support.
- Learners are motivated to use ICT resources when they are accessible and relevant to the curriculum.

1.8 Significance of the Study

The study is significant because it addresses one of the most pressing challenges in Zimbabwean education today the poor performance in science subjects, particularly Physics, in resource-constrained schools. By focusing on ICT integration, the study provides evidence-based insights that can guide teachers, school administrators, curriculum developers, and policymakers.

For teachers, the findings will highlight practical ways of using ICT tools to make Physics lessons more engaging and effective, even in the absence of laboratories and textbooks. For learners, ICT integration will provide opportunities to visualize abstract concepts, participate actively in lessons, and develop deeper conceptual understanding. For policymakers and curriculum developers, the study will offer guidance on how ICT can be mainstreamed into science education, in line with national goals of promoting STEM (Science, Technology, Engineering, and Mathematics) education and the Education 5.0 philosophy.

At a broader level, this research contributes to global discussions on the role of ICT in bridging educational inequalities between school which are resource rich and those that are resource-constrained. It also provides a framework that other countries facing similar challenges can adopt.

1.9 Limitations of the study

Like any research, this study has limitations.

- The research will be confined to one or a few resource-constrained schools, which may limit the generalizability of the findings.
- The availability of ICT tools may vary across schools, meaning findings may not represent all rural schools.
- Some teachers and learners may lack digital literacy skills, which could affect the level of ICT integration possible during the study.
- Power outages and poor internet connectivity, which are common in many parts of Zimbabwe, may limit the use

1.10 Delimitations of the study

The study is delimited to Ordinary Level Physics in selected resource-constrained secondary schools. It will focus on the integration of ICT tools such as virtual simulations, animations, videos, and mobile phone applications. The study does not cover other science subjects such as Chemistry or Biology, nor does it explore ICT use in non-science subjects.

Furthermore, the research will be limited to exploring ICT integration in teaching concepts within the current Physics curriculum. The study will not focus on ICT infrastructure development at a national level, but rather on classroom-level practices and experiences of ICT tools and influence the study results.

1.11 Definition of terms

ICT (Information and Communication Technology): Refers to digital tools such as computers, smartphones, projectors and internet resources used to enhance teaching and learning.

ICT Integration: The process of incorporating ICT tools into teaching and learning to improve instruction and learner engagement.

Physics Education: The teaching and learning of Physics concepts at secondary school level.

Resource-Constrained Schools: Schools that lack adequate teaching and learning materials such as laboratories, apparatus, textbooks and trained staff.

Virtual Laboratory: A computer-based simulation of a real laboratory that allows learners to perform experiments and observe results digitally.

Simulations: ICT tools that imitate real-life processes or experiments to help learners visualise and understand abstract concepts.

1.12 Organisation of the study

This study is organised into five chapters

Chapter 1 introduces the study, provides the background, statement of the problem, purpose, objectives, limitations, delimitations and definitions.

Chapter 2 reviews literature related to ICT integration in Physics teaching, theories of learning, and studies conducted in similar contexts.

Chapter 3 outlines the research methodology, including design, population, sample, instruments, and data collection procedures.

Chapter 4 presents and discusses the results.

Chapter 5 provides conclusions, recommendations and suggestions for further research.

1.12 Summary

This chapter introduced the study on integrating ICT tools in teaching Physics in resource-constrained secondary schools. It highlighted the importance of Physics education and the challenges faced in teaching the subject due to a lack of laboratories, apparatus, and textbooks. The background emphasized on the role of ICT in bridging the resource gap and improving learner engagement and performance. The purpose, research questions, assumptions, significance, limitations, and delimitations of the study were outlined. Key terms such as ICT, ICT integration and virtual laboratories were defined. The next, chapter, which is chapter two presented a review of literature related to the study.

2.0 CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction

The teaching and learning of Physics has always been a challenge especially in many rural Zimbabwean schools where resources are limited. According to MoPSE (2019) Physics is a subject that has always relied heavily on laboratory experiments, yet most schools do not have the required facilities. The coming in of ICT has opened new opportunities for bridging this gap. Computers, projectors, smartphones and even basic digital resources have been identified as tools that can make Physics more accessible and understandable to learners.

This chapter reviews literature related to the use of ICT in the teaching and learning of Physics at resource constrained schools. The purpose of this study is to evaluate what is already known, identify gaps and find ways of bridging these gaps. The review looks at ICT tools availability, their role in addressing shortages of laboratories and teaching and learning materials, challenges in adopting ICT and strategies for effective integration. The review is not only to describe what other researchers have said but also to critically analyse their findings in relation to the use of ICT tools. The discussion highlights what is already known, identifies areas where scholars agree or disagree and points out the gaps that still exist. In doing so, the chapter shows how this research contributes new knowledge to the field of Physics education, particularly in relation to secondary schools that do not have enough resources for the effective teaching and learning of physics.

2.2 Theoretical Framework

This study is underpinned by the constructivist theory of learning, originally proposed by Jean Piaget (1954) and later advanced by Jerone Brunner (1966). The theory posits that learners actively construct their own understanding and knowledge of the world through experiences and reflection, rather than passively absorbing information from teachers. Learning, therefore, is viewed as an active, contextualised process of meaning-making rather than the mere transmission of facts. With this view, knowledge is constructed through engagement, experimentation and interaction with tools, people and environment. In the context of Physics Education, this implies that learners grasp abstract science concepts more effectively when they

are directly involved in exploring, testing and visualising phenomena rather than only listening to explanations.

Piaget's (1954) constructivist approach emphasises the learner's active role in recognising existing cognitive structures through processes of assimilation and accommodation. Bruner (1966) further expanded this view by introducing discovery learning, which advocates that learners should be guided to uncover principles independently. For example, when Physicals students use interactive simulations to explore Newton's laws or energy conservation, they are not merely memorising formulas. Rather they are constructing understanding through inquiry and reflection. This approach mirrors real scientific investigation and promotes deeper conceptual understanding, an essential outcome for Physical education, particularly in resource-constrained schools where traditional laboratories experiments may not be feasible.

However, constructivism is not without criticism. Some scholars argue that the approach may place excessive cognitive demands on learners, especially when guidance is insufficient or when learners lack prior foundational knowledge (Clark, 2016). In resource-limited contexts, this challenge may be intensified by inadequate access to devices or internet connectivity. Nevertheless, these limitations can be mitigated through careful scaffolding of learning activities and thoughtful selection of ICT tools that match learners' cognitive levels. Teachers play a crucial role in structuring virtual experiments and providing guidance that ensures learners engage meaningfully rather than superficially.

Despite these criticisms, the constructivist framework remains very relevant to this study. It provides a robust theoretical foundation for understanding how ICT tools, such as virtual laboratories, interactive simulations and education videos can facilitate meaningful learning in Physics even where traditional resources are lacking. ICT platforms allow learners to manipulate variables, observe results and receive instant feedback, aligning precisely with constructivist principles of active participation and reflection. This theory therefore, justifies the integration of ICT in Physics teaching as an effective pedagogical approach that transforms abstract and teacher-centered instruction into learner-driven, interactive and practical experiences. In the Zimbabwean context, this aligns closely with Education 5.0, which prioritises innovation, experimentation and problem solving. As such, the constructivist theory not only

underpins this research but also supports national educational goals aimed at promoting creativity and producing graduates equipped with twenty-first-century skills.

2.2.1 Availability and Accessibility of ICT in Physics Teaching

Globally, the use of ICT in science education has improved learner engagement and comprehension. Studies by Stoumpos (2023) and NeoGov (2018) show that digital technologies such as real-time data systems and interactive simulations are being widely adopted to enhance learning efficiency and performance. The same principles can be adapted to Physics classrooms, where ICT facilitates experimental learning and promotes inquiry-based approaches. In resource-limited contexts such as Zimbabwe, ICT tools can act as ‘virtual laboratories,’ bridging the gap created by the lack of physical apparatus and textbooks. However as noted by Clark (2016), excessive reliance on unguided discovery learning can overwhelm learners, particular when they lack prior knowledge or adequate guidance. Therefore, ICT-based instruction should be carefully scaffolded by the teacher to ensure meaningful engagement rather than passive interaction with digital content.

Gudhlanga (2021) states that the integration of Information Communication Technology (ICT) in education had transformed teaching and learning across the globe and Physics education is no exception. This advent of digital learning tools such as virtual laboratories, simulations and interactive videos has redefined the way science concepts are taught and understood. According to Mtombeni (2024) technological innovation has become an integral component of modern education systems, influencing both teaching and learning processes. In Physics education, ICT tools have enabled learners to visualize abstract phenomena, conduct experiments virtually and engage more interactively with content, therefore, improving conceptual understanding and retention.

Access to ICT resources in Zimbabwean schools is uneven. Maringe (2017) states that urban schools often have computer labs, projectors, and internet, while most rural schools remain poorly resourced. Chinyoka and Naidu (2013) add that even when computers are donated in rural schools, their use is limited by lack of electricity and internet connection. MoPSE (2019) supports this view by admitting that the implementation of the ICT policy has been slow, leaving rural schools behind.

At the same time, there are noticeable signs of improvement of improvement indicating the possibility of in cooperating ICT tools in rural constrained schools. Ndlovu (2021) reports that smartphone ownership is rising among rural learners in Zimbabwe, and these devices are being used to access Physics simulations, YouTube demonstrations, and revision materials. However, Muringani (2018) points out that teacher preparedness remains an obstacle because many educators lack confidence in using technology such as laptops and other ICT tools, despite their availability. This shows that while ICT resources exist, their presence does not automatically mean that they will be used effectively or accessed in the classroom.

A study conducted in rural Gokwe by Ndlovu (2021) illustrates how learners were able to use smartphones for Physics learning despite not having computer labs. In this case, learners accessed online simulations and shared revision materials through WhatsApp groups. Teachers also used voice notes to explain difficult Physics concepts. However, the case also highlighted challenges such as high costs of data and network challenges. The case study shows that even where ICT resources are limited, learners and teachers are finding creative ways to use what they have.

Access to ICT resources in Zimbabwean schools remains uneven and largely dependent on geographic and economic context. Maringe (2017) observes that urban schools are often better equipped with computer laboratories, projectors and internet connectivity, while rural schools remain poorly resourced and struggle to integrate ICT in teaching. Chinyoka and Naidu (2016) further note that even when computers are donated to rural schools, their use is frequently hindered by lack of electricity, maintenance challenges and unreliable internet connectivity. The Ministry of Primary and Secondary Education (MoPSE, 2019) acknowledges that despite the national ICT policy, its implementation has been slow, leaving rural schools at a disadvantage.

Nevertheless, there are emerging signs of progress suggesting the potential for ICT incorporation even in resource-constrained contexts. Ndlovu (2021) reports that smartphone ownership among rural learners in Zimbabwe is increasing and these devices are being used to access online educational videos and revision materials. Similarly, Muringani (2018) points out that while ICT tools are gradually becoming available, many teachers remain underprepared to use them effectively. The lack of professional development and confidence in digital pedagogy often

limits the full utilisation of available ICT resources. This indicates that the presence of ICT infrastructure alone does not guarantee effective integration into teaching and learning processes.

A case study conducted by Ndlovu (2021) in Gokwe revealed that learners were able to use smartphones collectively to access Physics simulations and share revision materials via WhatsApp groups. Teachers supplemented these efforts with voice notes to clarify complex concepts such as electromagnetism and motion. However, persistent challenges such as high data costs, poor network coverage and inadequate digital literacy remain. These findings underscore the need for context-sensitive strategies that leverage available technology, however minimal, to enhance Physics education in under-resourced settings.

ICT tools such as virtual laboratories, computer simulations and interactive videos have emerged as powerful pedagogical instruments in the teaching of Physics. According to Brunner (1966) discovery learning allows learners to construct knowledge through exploration, an approach that resonates strongly with the interactive nature of ICT-based learning. Virtual laboratories, for instance, enable learners to conduct experiments that would otherwise be impossible due to lack of physical equipment. Through these tools, students can manipulate variables, observe outcomes and receive immediate feedback, promoting conceptual understanding and curiosity (Vygotsky, 1978).

ICT integration also has significant implications for educational equity. Yusuf and Balogun (2020) state that digital tools can reduce disparities in access to quality learning materials by providing low-cost alternatives to expensive laboratory setups. For example, online platforms such as PhET Interactive Simulations and YouTube Physics channels allow learners in rural areas to visualise experiments in real time. According to Gudhlanga (2021) such platforms enable learners to actively construct knowledge and test hypotheses, aligning with Education 5.0 vision of innovation, creativity and problem solving. Despite this potential, challenges persist. The digital divide manifested through unequal access to devices, electricity and internet, continues to limit effective ICT integration. As Murinani and Maringe (2017) argue, infrastructural barriers and inadequate teacher training remain key obstacles. However, to mitigate these, schools and policymakers must adopt sustainable models such as community-based ICT resources centers, solar-powered devices and teacher professional development in digital pedagogy.

Insights can also be drawn from global transformation trends in other sectors such as emergency services, where digital tools have enhanced efficiency and decision-making. Barnes (2013) highlights how technologies such as real-time data analytics, artificial intelligence (AI) and mobile applications have revolutionised service delivery across continents. In the same vein, integrating ICT tools into Physics teaching can improve monitoring, engagements and performance tracking. Just as digital mapping and AI have enhanced emergency response times, ICT in education can provide immediate feedback and adaptive learning opportunities, making instruction more responsive to individual learner needs. Countries such as Japan and South Korea have demonstrated that consistent investment in ICT infrastructure and teacher training can yield significant educational gains (Simsek, 2023). In contrast, many African nations, including Zimbabwe, continue to face barriers such as limited funding, weak policy implementation and inconsistent technological support (Nyamadzawo, 2017). However, local initiatives such as mobile-based learning and low-cost virtual lab software represent promising steps towards bringing the gap. This literature has shown that while integration in Physics education offers immense potential for improving learning outcomes, its success depends on equitable access, teacher competence and contextual adaption. Constructivist and socio-cultural theories provide a sound pedagogical rationale for this integration, emphasising learner-centered, interactive and inquiry-based approaches. For resource-constrained schools in Zimbabwe, ICT serves not merely as a substitute for missing laboratories and textbooks but as transformative tool capable democratising access to quality Physics education. The challenge now lies in ensuring that policy implementation, infrastructure structure development and teacher capacity-building efforts move in tandem to realise this vision. As such, the researcher shall investigate the availability and accessibility of ICT tools to teachers and learners for the teaching of Physics in resource-constrained schools.

2.2.2 Effective integration of ICTs to supplement the shortage of laboratories, apparatus and textbooks in Physics teaching and learning

Globally, studies emphasise that continuous technical support and system maintenance are as important as initial implementation (UNESCO, 2019). In the absence of such support structures, ICT adoption becomes episodic rather than transformative. For sustainable integration, MoPSE and local authorities need to institutionalise ICT maintenance through budget allocations,

partnerships with local tech firms, and training of in-school ICT champions who can provide first-line technical assistance. Yusuf and Balogun (2020) state that effective integration of Information and Communication Technologies (ICTs) in education remains one of the most promising solutions to address persistent shortages such as laboratories, textbooks and apparatus among other things. Physics by its nature, is a practical subject that requires experimentation and observation for learners to grasp fundamental concepts. However, in Zimbabwean schools, particularly in rural and peri-urban areas, laboratory facilities and instructional materials are either inadequate or completely unavailable. This situation has promoted educators and policymakers to explore ICT-based alternatives that can supplement or substitute traditional resources and provide learners with opportunities to engage meaningfully with scientific content.

When used effectively, ICT can transform the teaching and learning of Physics by making abstract phenomena visible, interactive and engaging. Gudhlanga (2021) observed that during the COVID-9 lockdowns, when physical classrooms were inaccessible, the use of WhatsApp lessons, simulations and online demonstrations allowed learners to interact with Physics concepts more actively than through textbooks alone. Chikasha (2019) found that learners in Harare who utilised virtual laboratories in studying mechanics showed improved conceptual understanding and performance compared to their peers taught through lecture-based instruction. These findings indicate that ICT not only provides access to alternative learning environments but also promotes learner-centred, inquiry-based pedagogy aligned with constructivist principles of education.

Sibanda (2020) reports that in Bulawayo, the introduction of animation and multimedia presentations made lessons more engaging and less intimidating for learners who previously viewed the subject as abstract and difficult. According to Muzenda (2016) teachers in Midlands Province observed significant improvement in learners' motivation and comprehension when they integrated ICT tools such as PowerPoint presentations, educational videos and interactive simulations into their teaching. These local findings resonate with international research. Perkins (2016) demonstrated that simulations enhance learners' understanding of complex Physics topics such as electricity and magnetism by allowing them to manipulate variables and visualise relationships that are otherwise invisible. Likewise, Wieman (2015) confirmed that students

exposed to virtual laboratories outperform those taught using traditional chalk-and-talk methods. This suggests that ICT integration leads to deeper conceptual learning and retention.

In Zimbabwe, the lack of laboratory equipment and modern textbooks remains a major impediment to effective Physics instruction. Chikasha's (2019) study in Harare provides a compelling case study on how ICT can effectively substitute for traditional laboratories. Learners were introduced to virtual experiments in Mechanics, enabling them to conduct investigations repeatedly, adjust parameters and instantly observe results. These outcomes revealed improved test performance and greater enthusiasm among learners. Many participants expressed that they enjoyed experimenting in the virtual environment because it eliminated the fear of breaking expensive apparatus, a common concern in under resourced schools. As a result, in the school understudy, it was also noted that the laboratory equipment was often reserved for examinations. In the case of Chikafas' (2019) study, teacher on the other hand, reported that ICT-based teaching reduced pressure on limited physical resources and provided opportunities to demonstrate experiments that would otherwise be impractical due to safety or cost constraints.

When used effectively, ICT has been shown to transform Physics learning in Zimbabwe. When ICT is applied effectively, it can improve Physics learning outcomes. Mafa and Gudhlanga (2021) observed that during the COVID-19 lockdowns, WhatsApp lessons and simulations helped learners engage more actively with Physics concepts than using textbooks only. Chikasha (2019) found that learners in Harare who used virtual laboratories had a better performance in mechanics compared to those taught only by lecturing notes.

Sibanda (2020) further reports that in Bulawayo, animations and multimedia increased learner motivation and made Physics feel more approachable. Similarly, according to Muzenda (2016) teachers in Midlands Province saw improved learning outcomes when they used ICT tools. International research such as Perkins et al. (2006) supports, that simulations help learners understand challenging topics such as electricity, while Wieman and Perkins (2005) confirm that students taught with virtual labs perform better than those using traditional learning methods.

In a study carried out by Chikasha (2019) in Harare, learners were introduced to virtual laboratories for Mechanics lessons. The outcome showed that learners performed better in tests compared to those taught using traditional methods. The learners reported that they enjoyed

using the computer and could repeat experiments multiple times without fear of breaking equipment. Teachers also found the approach useful, especially since many schools in Harare struggle to maintain fully equipped laboratories. This case study demonstrates how ICT can effectively substitute for traditional laboratories in schools.

The effectiveness of ICT integration extends beyond immediate learning outcomes. It also contributes to building digital literacy and problem solving skills among learners (Yusuf and Balogun, 2020). According to Gudhlanga (2021) ICT-supported learner encouraged curiosity, innovation and independent exploration, qualities essential for scientific inquiry and aligned with Zimbabwe's Education 5.0 philosophy. Through interactive simulations and virtual experiments, learners develop critical thinking and analytical skills as they test hypotheses, interpret data and refine their understanding based on real-time feedback. This aligns with Vygotsky's (1978) socio-cultural perspective, which emphasises learning through interaction with tools and collaboration with peers.

However, while ICT integration presents immense potential, it is not without challenges. Many teachers in resource-constrained schools lack adequate training in using ICT for pedagogical purposes. Muringani (2018) notes that even when digital tools are available, limited teacher competence and confidence often hinder their effective use. In addition, infrastructural challenges such as poor electricity supply, insufficient devices and unreliable internet connectivity continue to restrict access, particularly in rural areas (MoPSE, 2019). Nevertheless, innovative approaches have emerged to address these limitations. For example, Ndlovu (2021) documents how teachers and learners in Gokwe utilised smartphones and WhatsApp groups to share learning materials, simulations and voice explanations, demonstrating that even low-cost digital tools can significantly enrich the learning experiences when used creatively.

Given, the above, ICT can act as powerful equaliser in contexts where educational resources are scarce. Virtual laboratories, educational videos and mobile learning platforms can bridge the gap between theory and practice by providing experiential learning opportunities that would otherwise be inaccessible. As Muzenda (2016) highlights, when Physics lessons incorporate multimedia and interactivity, learners are more likely to connect theoretical concepts with real-world applications. This transformation from passive reception to active participation redefines the learning environment, fostering curiosity and deeper comprehension.

It therefore, shows that, the effective integration of ICT tools in Physics education provides a sustainable and innovative solution to the chronic shortage of laboratories, apparatus and textbooks in Zimbabwean schools. Evidence from both local and international research consistently demonstrates that ICT can enhance engagement, motivation and performance when applied pedagogically and contextually. Although challenges persist, especially in rural areas, the creative use of available digital tools, coupled with targeted teacher training, can enable even resource-limited schools to deliver high-quality Physics education. As such, ICT integration should not be viewed merely as a temporary substitute for physical resources but as a transformative pedagogical strategy that redefines how Physics is taught and learned in the twenty-first century. Therefore, the researcher shall examine the effective integration of ICTs to supplement the shortage of laboratories, apparatus and textbooks in Physics teaching and learning.

2.2.3 Challenges teachers and learners face in the integration of ICT in Physics education

The integration of Information and Communication Technologies (ICTs) in education has been widely recognised as a pathway to improving teaching quality, learner engagement and overall academic performance. However, despite its potential benefits, several persistent challenges hinder the full adoption and effective utilisation of ICT tools in Physics classrooms, especially in developing contexts such as Zimbabwe. These challenges span across infrastructural constraints, teacher preparedness, socio-economic inequalities, policy gaps and limited technical support. In many Zimbabwean schools, inadequate infrastructure remains the foremost barrier to effective ICT integration. The Ministry of Primary and Secondary Education (MoPSE, 2019) acknowledges that poor infrastructure, particularly the absence of reliable electricity and internet connectivity, is a major obstacle, especially in rural schools. According to Ndlovu (2021), schools in provinces such as Masvingo, Gokwe and Binga often operate without stable power sources, rendering computers, projectors and other ICT equipment unusable for most of the school year. Similarly, Muringani (2018) observes that in Manicaland Province, numerous computers remain idle due to power outages and the absence of qualified technicians to maintain or repair them.

This infrastructural deficit extends to the lack of adequate hardware and software resources. Many schools possess out-dated computers, incompatible programs or limited bandwidth, restricting access to online learning platforms. In some cases, ICT equipment donated by NGOs or government initiatives becomes obsolete or underutilised because of poor maintenance plans. As Gudhlanga and Mafa (2021) argue, ICT integration cannot thrive where schools lack consistent access to functional infrastructure, affordable data or updated software systems. Consequently, infrastructural challenges form the foundation upon which other ICT-related problems are built.

Teacher capacity and attitudes significantly influence the successful implementation of ICT in Physics education. Many Physics teachers in Zimbabwe were trained before the advent of digital learning technologies, leading to a gap between their pedagogical training and modern technological demands. Mlambo (2019) notes that teachers often feel inadequately prepared or even intimidated by the introduction of computers, simulations and online resources into the classroom. As a result, they tend to rely on traditional lecture-based methods that limit interactive learning opportunities. Furthermore, the lack of continuous professional development exacerbates this problem. While some schools occasionally organise ICT workshops, these are often short-lived and fail to build lasting competence (Mafa, 2018). Studies in other African contexts reflect similar trends. For instance, Omodan and Ige (2020) found that in Nigerian secondary schools, teachers' reluctance to use ICT stemmed from low confidence, fear of failure, and inadequate administrative support. When teachers lack both the technical know-how and the pedagogical understanding of how to integrate digital tools effectively, ICT remains peripheral to Physics instruction.

Moreover, attitudes toward ICT play a crucial role. Chikasha (2019) highlights that some teachers view technology as an additional workload rather than a tool that can simplify instruction. Others worry that ICT might diminish their authority in the classroom or render them less relevant. Therefore, cultivating positive teacher attitudes, through mentorship, peer learning, and incentives, remains central to overcoming resistance and promoting meaningful ICT integration in Physics education. The benefits of ICT in Physics learning are often unevenly distributed because of socio-economic disparities among students. Chinyoka (2013) highlights that many learners from low-income households cannot afford smartphones, laptops, or data

bundles required for e-learning. This inequality creates a digital divide within classrooms—where some learners can access simulations and online tutorials outside school, while others rely solely on limited in-class resources.

During the COVID-19 pandemic, these inequalities became more visible. According to Mafa and Gudhlanga (2021), learners in urban areas who had access to WhatsApp and internet-enabled devices continued learning through online lessons, whereas most rural learners were left behind. This disparity perpetuates educational inequality and undermines the principle of inclusive education. The situation is further worsened by gender-based disparities, where female students, especially in rural areas, often have less access to personal digital devices due to cultural or financial reasons (UNESCO, 2021). The digital divide does not only affect learners' access to technology but also their ability to participate confidently in ICT-based Physics learning. For instance, Ndlovu (2021) found that learners in Gokwe who used shared smartphones for Physics simulations often had limited time to explore concepts deeply, reducing the intended learning impact. Addressing socio-economic barriers thus requires targeted interventions, such as government-subsidised data, shared devices or offline digital content, to ensure equitable access and participation.

Although Zimbabwe's education policy framework, including Education 5.0 and the National ICT Policy (2016), recognises the importance of technology in education, implementation remains inconsistent. Gudhlanga and Mafa (2021) argue that there is a disconnection between policy aspirations and the realities on the ground. For example, while Education 5.0 encourages innovation and digital literacy, many schools lack clear guidelines or frameworks for integrating ICT into daily teaching. Policy implementation is further hindered by inadequate funding and weak coordination between stakeholders. Dzvimbo (2020) observes that many schools rely heavily on donor-funded ICT projects that are rarely sustained once external funding ends. Similarly, Choga and Nyamadzawo (2020) note that while ICT policies emphasise teacher training, there is no systematic mechanism to ensure that all teachers undergo regular professional development. The result is a fragmented approach where some schools make progress independently while others lag far behind.

Institutional support is also critical. Many school heads and administrators lack the necessary management skills to drive ICT adoption, resulting in poor planning and monitoring. Without leadership commitment and policy enforcement, ICT tools often remain underutilised. In contrast, studies from Kenya and South Africa (UNESCO, 2020) show that strong institutional leadership, combined with national policy enforcement, significantly improves ICT integration outcomes. Zimbabwe's success in this area will depend on closing the gap between policy design and practical implementation. A major yet often overlooked challenge in ICT integration is the lack of on-going technical support for both teachers and learners. Once equipment is installed, schools often struggle to maintain it due to the absence of ICT technicians or trained staff (Muringani, 2018). In Manicaland, for example, a study revealed that several computers remained idle for months because of minor technical issues such as software errors or network configuration problems (Mlambo, 2019). Teachers, already burdened with academic duties, rarely have the technical expertise to troubleshoot these issues.

In addition, most ICT integration initiatives lack sustainability plans. Projects introduced through donor support or pilot schemes often fail once funding ends (Ndlovu, 2021). This leads to situations where schools possess sophisticated ICT tools that cannot be used due to lack of maintenance, replacement parts, or operational budgets. The absence of a dedicated ICT coordinator or technician in most Zimbabwean schools means that even small challenges can derail digital learning efforts for extended periods.

An illustrative example of these challenges can be drawn from Mlambo's (2019) study in Manicaland, where solar-powered ICT hubs were introduced to improve teaching and learning. While the initiative successfully provided computers and sustainable power solutions, teachers lacked the training to fully integrate ICT tools into Physics lessons. Learners also struggled with basic computer literacy, making it difficult to use simulations effectively. The project underscored that solving infrastructural problems alone is insufficient; teacher competence, learner readiness, and curriculum alignment must also be addressed simultaneously. This case demonstrates the interdependence of different factors influencing ICT integration. Infrastructure without training, technology without policy, and innovation without sustainability all lead to underutilisation. Therefore, a holistic approach is required, one that combines energy access, digital literacy, teacher empowerment, and consistent support, to ensure lasting benefits. As a

result, the review has shown that, the integration of ICT in Physics education faces multifaceted challenges that extend beyond simple access to technology. Infrastructural deficiencies, low teacher confidence, socio-economic disparities, policy implementation gaps, and limited technical support collectively constrain progress. These challenges highlight the need for comprehensive, context-specific solutions that prioritise capacity building, equitable access, and institutional sustainability. Addressing these obstacles is essential if ICT is to move from being a peripheral aid to becoming a transformative force in Physics education across Zimbabwe.

Although the use of ICT tools has a lot of benefits, challenges still remain. According to MoPSE (2019) poor infrastructure is the greatest challenge, many rural schools do not have electricity and internet. Ndlovu (2021) supports this by noting that rural schools also struggle to find funds or donations to be able to maintain ICT equipment. Similarly, Muringani (2018) explains that in Manicaland, many computers are idle because of power cuts and also a lack of technical support.

In addition, teacher confidence is a major challenge faced in the integration of ICT in physics education. Mlambo (2019) notes that teachers trained before ICT became common but are not comfortable with new methods and prefer traditional teaching methods. Furthermore, Chinyoka (2013) highlights the issue of inequality, as not all learners can afford smartphones or data bundles, making ICT-based learning unfair. On a policy level, Gudhlanga and Mafa (2021) argue that although Education 5.0 promotes ICT, there is no proper guidance and training for schools on how to use it daily in science classrooms. This shows that even when ICT is available, systemic barriers often prevent its effectiveness.

Mlambo (2019) documented a project in Manicaland where solar-powered ICT hubs were introduced to support teaching and learning in secondary schools. The hubs were shared by other schools nearby, giving learners access to computers and digital resources. While the initiative improved access, the study found that teachers lacked adequate training to fully introduce ICT into Physics lessons. In addition, some learners still struggle to use the equipment confidently. The case highlights that infrastructure solutions, such as solar energy, must be matched with teacher training and curriculum integration to achieve sustainable use of ICT tools. Therefore, the researcher shall examine the challenges teachers and learners face in the integration of ICT in Physics education.

2.2.4 Strategies to enhance the effective adoption and utilization of ICT tools in Physics teaching and learning

Researchers suggest several ways to overcome these barriers. Mafa (2018) recommends that teachers need more regular workshops and trainings to build confidence in using ICT, especially virtual labs and simulations. In the same way, Dzvimbo (2020) points out that partnerships between universities and secondary schools can help by sharing resources and expertise.

On infrastructure, Mlambo (2019) describes successful solar-powered ICT hubs in Manicaland that allowed schools to share equipment. Similarly, World Vision Zimbabwe (2019) piloted solar-powered learning centers in rural districts, proving that renewable energy can support ICT access. Gudhlanga and Mafa (2021) further assert that ICT should be fully integrated into the curriculum rather than treating it as an optional tool. These strategies show that ICT integration can succeed in resource constrained schools if teacher training, infrastructure and community support are prioritised.

Yusuf and Balogun (2020) posit that one of the most critical factors influencing the successful integration of ICT in education is the professional competence and confidence of teachers in using digital tools. Studies consistently show that teachers' pedagogical beliefs, attitudes, and digital literacy levels determine the extent to which ICT tools are adopted in classroom practice (Tondeur et al., 2017; Mafa, 2018). In Zimbabwe, Mafa (2018) and Gudhlanga and Mafa (2021) emphasise that many Physics teachers were trained under curricula that prioritised chalk-and-talk methods, with little exposure to virtual laboratories, simulations, or blended learning platforms. As a result, even when ICT infrastructure is made available, teachers may underutilise it due to lack of confidence or familiarity.

Effective teacher professional development (TPD) should therefore focus on both technical and pedagogical aspects of ICT integration. Mafa (2018) suggests that workshops and continuous professional development programmes be designed to build teachers' competence in using virtual labs, simulations, and educational applications that align with the Zimbabwean Physics syllabus. These training programmes should move beyond one-off events and adopt a sustained, mentoring-based model that allows teachers to share experiences and collaboratively solve challenges. Internationally, Wieman and Perkins (2005) found that teachers who received guided

training on using PhET simulations demonstrated a significant improvement in classroom ICT use and student engagement.

Moreover, professional learning communities (PLCs) have been shown to foster peer collaboration and continuous skill development (Fullan, 2019). In the Zimbabwean context, such communities could be established within school clusters or district education offices, supported by the Ministry of Primary and Secondary Education (MoPSE). Online platforms such as WhatsApp and Google Classroom can serve as collaborative forums for Physics teachers to exchange ideas and resources. As such, building teachers' confidence and competence is the foundation upon which effective ICT integration in Physics teaching rests.

The availability of reliable ICT infrastructure remains a major determinant of successful digital integration in resource-constrained schools. In rural and peri-urban Zimbabwe, many schools struggle with unreliable electricity, inadequate computers and poor internet connectivity (Dzvimbo, 2020). Without addressing these infrastructural barriers, even the most enthusiastic teachers will face limitations in implementing ICT-supported instruction. Mlambo (2019) highlights successful case studies from Manicaland Province, where schools established solar-powered ICT hubs that allowed multiple institutions to share equipment and digital resources. Similarly, World Vision Zimbabwe (2019) demonstrated that solar-powered community learning centres can sustain computer-assisted learning even in off-grid areas.

Infrastructure improvement extends beyond providing physical devices to ensuring regular maintenance and equitable access. Schools need structured ICT policies for device management, software updates, and network security. According to Gudhlanga and Mafa (2021), partnerships with private telecommunications companies such as Econet Wireless and TelOne could provide subsidised internet access and technical support to rural schools. In Kenya, the eLimu and BRCK Education initiatives have shown how low-cost tablets preloaded with educational content can function effectively in low-resource settings (UNESCO, 2020). As such, Zimbabwe can adapt similar models by developing digital Physics content that is accessible offline, especially simulations and video tutorials aligned with the national curriculum.

Furthermore, Mlambo (2010) states that schools can adopt a “shared resource” approach, where clusters of neighbouring schools jointly establish ICT centres or digital laboratories. Such resource pooling reduces cost burdens and promotes community ownership. Infrastructure development, therefore, requires innovative, context-sensitive approaches that combine renewable energy, community participation and public-private partnerships to create sustainable digital ecosystems in Physics education.

According to Mafa (2020) a key strategy for ensuring the effective utilisation of ICT tools lies in embedding digital resources into the Physics curriculum, rather than treating them as supplementary or optional. Gudhlanga (2021) argue that ICT must be an integral component of curriculum design, pedagogy and assessment. When ICT is disconnected from learning outcomes, teachers may view it as an add-on rather than a core instructional tool. In Zimbabwe, the new competency-based curriculum introduced by the Curriculum Framework (2015–2022) provides an opportunity to mainstream ICT integration, particularly in STEM subjects.

Pedagogical alignment involves redesigning lesson plans to integrate simulations, animations, and digital experiments into Physics topics such as electricity, optics, and motion. Perkins (2016) demonstrated that students who engaged with digital simulations developed a deeper conceptual understanding compared to those who only observed physical demonstrations. Similarly, Perkins (2015) reported that interactive virtual labs not only improve comprehension but also enhance critical thinking and problem-solving skills. For example, a teacher can use the PhET “Circuit Construction Kit” to allow students to explore electrical circuits virtually before conducting a limited hands-on experiment with actual materials. Mafa (2020) posits that curriculum integration should also extend to assessment methods. Teachers can use ICT-based formative assessments, such as quizzes delivered through Google Forms or Moodle, to provide immediate feedback and track learning progress. International examples, such as Singapore’s Smart Learning Schools initiative (MOE, 2021), demonstrate how digital formative assessments can complement practical experiments to improve Physics learning outcomes. For Zimbabwe, aligning ICT with curriculum delivery will require MoPSE to provide digital content repositories, train teachers in digital pedagogy and develop assessment frameworks that value ICT-facilitated learning.

The successful integration of ICT in Physics education requires a coordinated, multi-stakeholder approach involving the government, schools, teachers, parents, NGOs and the private sector. Dzvimbo (2020) highlights that partnerships between universities and secondary schools are essential for sharing resources, research findings and expertise. For instance, university Physics departments could mentor teachers in simulation use or digital lab development, while education technology companies could supply affordable equipment and maintenance services.

Policy support at national and institutional levels plays a decisive role. The National ICT Policy of Zimbabwe (2016) calls for the promotion of e-learning and digital literacy across all levels of education. However, its implementation has been inconsistent due to funding and coordination challenges (Mafa, 2018). Establishing clear operational frameworks that mandate ICT integration in science education would strengthen accountability and resource allocation. In Botswana, the Ministry of Education's ICT Master Plan (2017–2022) offers an instructive model, outlining detailed targets for teacher training, ICT infrastructure, and curriculum digitalisation.

At the community level, involving parents and School Development Committees (SDCs) can increase sustainability. When parents understand the value of ICT in improving learning outcomes, they are more likely to contribute towards maintenance and resource mobilisation. NGOs such as Plan International and UNICEF have successfully mobilised communities in Zimbabwe to support digital education initiatives through device donations and school connectivity projects (UNICEF, 2022). Therefore, collaboration among all education stakeholders ensures that ICT integration in Physics is not a top-down policy but a shared commitment rooted in collective responsibility.

In contexts where schools face acute shortages of laboratories, textbooks and equipment, Open Educational Resources (OER) and mobile learning platforms offer cost-effective alternatives. OER are freely available teaching and learning materials that can be accessed, adapted and shared without licensing restrictions (UNESCO, 2020). These include online simulations, video tutorials, digital textbooks, and interactive quizzes. In Physics, platforms such as PhET Interactive Simulations, YouTube Science Channels and the Open University's Open Learn provide valuable digital content for both teachers and students. Muzenda (2016) found that the use of multimedia and animations in Zimbabwean classrooms increased learner motivation and

improved understanding of abstract Physics concepts. Gudhlanga (2021) observed that during the COVID-19 lockdown, mobile-based lessons via WhatsApp helped sustain learning continuity in resource-limited schools. Mobile phones, being more accessible than computers, can thus serve as powerful tools for interactive learning. In Kenya, the Eneza Education platform delivers science lessons and quizzes via SMS and web interfaces, providing a replicable model for Zimbabwean Physics teaching (Eneza, 2020).

Furthermore, combining OER with locally developed digital content ensures contextual relevance. Teachers can create short video demonstrations of experiments using smartphones, upload them to school-based platforms and share them offline through flash drives or Bluetooth. This hybrid approach, merging global OER with locally contextualised materials, enhances learner engagement and knowledge retention. Integrating these innovations into formal teaching plans promotes learner-centred, inquiry-based learning, even where physical laboratories are lacking. As a result, the review has shown that the integration of ICT tools in Physics education, especially in resource-constrained schools, requires a multidimensional approach that combines teacher empowerment, infrastructure investment, curriculum alignment, stakeholder cooperation and innovative use of digital resources. These strategies are mutually reinforcing, teacher training is meaningless without infrastructure and infrastructure alone cannot drive meaningful change without supportive policy and pedagogy. Therefore, a holistic model that embeds ICT within the broader educational ecosystem will enable Zimbabwean schools to overcome laboratory shortages and enhance Physics teaching and learning for all learners.

2.7 Establishing the Knowledge Gap

While several Zimbabwean studies give useful insights, most of them only discuss ICT as a communication or supplementary tool. For example, Mafa (2018) and Chikasha (2019) focused on ICT for lesson delivery, while Muringani (2018) and Ndlovu (2021) mainly examined access and challenges. Very few studies look at ICT as a complete substitute for Physics laboratories, especially in rural schools where apparatus and textbooks are completely absent. There is also little research on how ICT affects problem-solving, critical thinking, and long-term learner performance.

This study therefore seeks to fill that gap by focusing on ICT as an alternative to laboratories in Physics teaching and learning in Zimbabwe's resource-constrained schools.

2.8 Summary

This chapter reviewed studies on ICT in Physics education, with a focus on resource constrained schools in Zimbabwe. It indicated that ICT aligns with constructivist and socio-cultural theories, which stress active learning. According to existing research, ICT tools can improve engagement and understanding, but availability alone does not ensure the correct use, especially in rural schools. The main challenges are poor infrastructure, weak teacher training, and unclear policies. At the same time, scholars such as Mafa (2018), Mlambo (2019), and Gudhlanga and Mafa (2021) suggest practical solutions such as teacher training, community ICT hubs and solar power. The three case studies further illustrated how ICT is being applied in different contexts, rural learners in Gokwe using smartphones, urban schools in Harare experimenting with virtual labs, and solar-powered ICT hubs in Manicaland. Each case highlighted both the benefits and the challenges of ICT use in Physics teaching and learning. The review concluded that there is still a clear knowledge gap on how ICT can be used as a full substitute for laboratories in Physics teaching and learning. Addressing this gap is the main focus of this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter focused on the research methodology used to gather data. Research methodology refers to the process of collecting information and data to support decision-making. It encompasses the methods employed to gather data in order to ensure the reliability and validity of the research findings. The research methodology used in this study includes the research design, target population, sample and sampling procedures, research instruments, data collection procedures and data analysis procedures.

3.2 Research Design

3.2.1 Research Paradigm/Philosophy

This study adopted an interpretivist paradigm. According to Saunders, Lewis, and Thornhill (2019), interpretivism is based on the belief that reality is socially constructed and subjective, meaning that people interpret events differently according to their personal experiences. This paradigm addresses three components:

- 1. Ontology:** Reality is subjective and depends on individuals' perceptions and experiences.
- 2. Epistemology:** Knowledge is obtained through understanding participants' perspectives and lived experiences.
- 3. Axiology / Ethics and Values:** Researchers acknowledge their values and strive to conduct research ethically, respecting participants' perspectives and well-being.

The interpretivist paradigm guided the study in understanding the experiences of Physics teachers and learners in integrating ICT tools in resource-constrained classrooms.

3.2.2 Research Design

According to Oyedele (2018) research design is the framework that holds the research project together. It structures the research process and demonstrates how the different components of the

study work together to address the central research questions. The research design also outlines the overall strategy chosen to integrate the study's various elements in a coherent and logical manner, ensuring effective addressing of the research problem. Oyedele (2017) adds that a research design is the plan and structure of an investigation, providing a blueprint for the collection, measurement and analysis of data. In this study, a case study was suitable to evaluate the integration of ICT tools in teaching and learning Physics in resource-constrained schools.

3.2.3(Case Study)

According to Kothari (2018) a case study allows researchers to explore phenomena in depth and within their natural settings, making it a valuable method for understanding intricate social processes. Wolcott (2017) emphasises that case studies focus on the particularities of the case, providing rich descriptive data that can reveal patterns and themes. Wolcott (2017) adds that case studies are effective for exploring how and why questions, making them suitable for understanding the dynamics of social work practice. Therefore, a case study is a detailed examination of a specific individual, group, or situation, often used to gain insights into complex issues in real-world contexts.

The effectiveness of case studies lay in their ability to provide in-depth insights that quantitative methods may overlook (Kothari, 2018). In the context of this research, a case study approach allowed for a detailed exploration of the integration of ICT tools in teaching and learning Physics in resource-constrained schools, making a case of a secondary school in Zvimba. However, one potential shortcoming of case studies is the limited generalisability of findings due to the focus on a specific context. Nevertheless, Wolcott (2017) stated that to address this, the researcher could triangulate data by incorporating multiple sources, such as interviews and observations, to enhance the validity of the findings. Despite these limitations, case studies remained an ideal option for this research because they facilitated a comprehensive understanding of the unique challenges within a specific institutional setting. In this study, a mixed methods approach was employed to complement the case study design and enhance the depth and validity of the findings. Questionnaires were used to gather structured, quantifiable information from Physics teachers about their use and perceptions of ICT tools, while interviews provided richer, in-depth insights into their experiences, challenges and strategies. Classroom observations allowed the researcher to directly see how ICT tools were being integrated into teaching and learning,

providing contextual data that may not be captured through self-reported instruments. Using multiple methods enabled triangulation, which strengthened the credibility of the findings by cross-verifying information from different sources. Therefore, the integration of questionnaires, interviews and observations ensured a comprehensive understanding of ICT integration in Physics lessons, combining numerical data with descriptive, contextual evidence to address the research questions more effectively.

3.3 Data Collection Methods/Instruments

According to Creswell (2016) research instruments are used to collect data when carrying out a research. Research instruments are tools used to collect data for analysis (Mayer, 2015). In this study, the questionnaire and interviews were employed as research instruments. Research instruments are tools used by the researcher to collect data that is related to the research problem, (Chiromo, 2016). Research instruments can be either interviews, questionnaires, observation and others to collect data. In this study, the research instruments to be used are questionnaires, key informant interviews and lesson observations.

3.3.1 Questionnaires

Questionnaires were used to gather data from Physics learners. According to Kothari (2004), a questionnaire is a set of questions prepared and sent to respondents to obtain information about a specific issue. Orodho (2015) defines a questionnaire as a tool for collecting data through written responses to a series of questions. Therefore, a questionnaire is a written instrument designed to gather information from participants in a structured and consistent way. Best and Kahn (2016) highlighted that questionnaires were advantageous because they could reach many people at once, save time, and allow respondents to answer at their own pace. However, they also had disadvantages such as low response rates, misunderstanding of questions, and lack of opportunity for clarification. To mitigate these challenges, the researcher made the questions short and clear, explained the purpose of the study to encourage participation, and assured respondents of confidentiality. Follow-ups were conducted to ensure more questionnaires were returned.

Through the questionnaires, the researcher obtained structured information from Physics learners regarding their experiences with ICT integration, challenges faced in learning without laboratories, and perceptions of how ICT tools could enhance their understanding. The

quantitative data collected provided a clear overview of the availability and use of ICT tools, which complemented the richer qualitative insights from interviews and classroom observations, allowing the researcher to address the objectives of the study systematically.

3.3.2 Interviews

Interviews were conducted with two Physics teachers. According to Kvale (1996), an interview is a conversation with a purpose, used to obtain descriptions of the interviewee's lived world concerning the interpretation of the meaning of the described phenomena. Cohen, Manion and Morrison (2018) define an interview as a purposeful interaction in which one person obtains information from another through a series of questions and responses. Therefore, an interview is a structured or semi-structured conversation designed to gather detailed information, opinions, or experiences from participants on a specific subject. During the interviews, the person being interviewed was considered the expert and the interviewer was regarded as the student. The interviewing techniques were motivated by the desire to learn as much as possible from the participants.

Leedy (2016) asserted that participants are engaged in in-depth interviews by posing questions in a neutral manner, listening attentively and actively to participants' responses, and asking follow-up questions and probes based on their answers. Creswell (2016) noted that the advantages of in-depth interviews include giving the researcher control over the line of questioning, their usefulness when participants cannot be directly observed, and their ability to provide an interpretive perspective on the connections and relationships a person sees between particular events, phenomena, and beliefs. The disadvantages include providing indirect information filtered through the views of the interviewee, the possibility of biased responses due to the researcher's presence, and the fact that not all people are equally articulate or perceptive, which presented challenges during data collection.

To overcome these challenges, the researcher ensured that questions were clear, neutral, and focused to minimise bias. Follow-up questions were used to seek clarification and ensure accurate understanding of responses. All interviews were recorded and transcribed carefully to capture participants exact words. In addition, interviews were scheduled efficiently to manage time and avoid fatigue for both the researcher and participants.

Through interviewing Physics teachers, the researcher obtained detailed insights into the challenges they faced in teaching practical Physics without laboratories and the strategies they employed to promote effective learning under such conditions. The interviews provided rich, first-hand information on teachers' perceptions of resource shortages, their coping mechanisms, and their views on possible improvements in the teaching of Physics in rural secondary schools. This qualitative data complemented the questionnaire findings and helped the researcher answer questions related to both the constraints and the innovative strategies used in teaching practical Physics in resource-constrained environments.

3.3.3 Observations

Classroom observations were conducted to examine how ICT tools were being integrated into the teaching and learning of Physics. The observation checklist included items such as how teachers used ICT tools during lessons, learner participation when ICT tools were employed, the availability and functionality of ICT equipment, the level of teacher competence in operating ICT tools, and how ICT integration enhanced learners' understanding of Physics concepts.

According to Morrison (2018), observation is the systematic viewing of people's actions and the recording, analysis, and interpretation of their behaviour. Best and Kahn (2016) defined observation as a purposeful, systematic, and selective way of watching and listening to an interaction or phenomenon as it occurred. Therefore, observation was a structured process of watching, recording, and interpreting behaviours or events in their natural setting to gain insights into real practices. Morrison (2018) highlighted that one advantage of observation was that it allowed the researcher to see real behaviour as it happened, rather than relying solely on what people said. Best and Kahn (2016) added that observation provided rich, detailed information about teaching and learning processes. However, observation also had disadvantages, including potential observer bias, where the researcher's presence or interpretation affected what was seen, and the fact that it could be time-consuming and limited to specific situations.

To address these challenges, the researcher used a clear observation checklist to remain objective, conducted several observations to obtain a more accurate picture, remained as discreet as possible to reduce influence on participants, and carefully planned observation sessions to save time.

By observing actual classroom practice, the researcher could verify how ICT tools were being applied during Physics lessons and how learners interacted with these tools. Observations provided direct, real-time evidence of ICT integration, highlighting practical strategies employed by teachers, as well as the challenges faced. This evidence complemented the findings from questionnaires and interviews, enabling the researcher to triangulate data and present a more comprehensive understanding of ICT use in resource-constrained Physics classrooms

3.4 Population, Sample and Sampling Techniques

3.4.1 Population

The population of the study consists of Physics teachers and form 3 learners at the secondary school. According to Creswell (2014) a population is the larger group from which a sample is drawn, encompassing all individuals who meet the study's criteria. Mayer (2015) defines population as the totality of individuals or items that are the subject of the research and from which conclusions are drawn. In addition, Kothari (2014) describes population as the complete set of observations or measurements that researchers are interested in studying, which can lead to generalizations about the entire group based on the sample analysed. Therefore, in research, the term 'population' refers to the entire group of individuals or elements that share specific characteristics relevant to the study. It is from this population that the target population was identified and drawn.

3.4.2 Target population

The study's target population is composed of 2 Physics teachers and 43 form 3 learners. According to Creswell (2014) the target population consists of those individuals who meet the specific criteria relevant to the research questions and objectives. Mayer (2015) describe the target population as the particular subset of the larger population that the researcher intends to sample from, ensuring that the findings are applicable to that specific group. Trochim (2006) highlights that clearly defining the target population is crucial for effective sampling and for ensuring that the research results can be generalized to the desired group. Therefore, a target population refers to the specific group of individuals that a researcher aims to study and draw conclusions about. The study targeted the Physics teachers and learners. These made up 2 teachers and 43 learners. It is from this target population that the study shall draw the sample.

3.4.3 Sample

The sample consisted of 14 participants selected from the target population using purposive and random sampling techniques. Purposive sampling identified all 2 Physics teachers, while random sampling selected 12 learners to ensure representativeness and minimize bias. A sample, as defined by Wolcott (2017) is a finite part of a statistical population whose properties are studied to gain information about the whole

3.4.4 Sampling Techniques

In order to draw a sample of 14 participants, purposive sampling and random sampling was done. Purposive sampling was done to draw the sample of teachers. According to Kothari (2018) a sampling technique refers to the method or procedure used by a researcher to select a portion of the population for study in such a way that it represents the characteristics of the whole population. Creswell (2016) defines a sampling technique as the specific process through which individuals, groups or elements are chosen from a larger population to participate in a research study, ensuring that data collected can be generalised or meaningfully interpreted. Therefore, a sampling technique is the systematic method used by a researcher to select participants or elements from a population in order to obtain information that accurately reflects the characteristics of that population. Sampling techniques are broadly categorised into probability sampling techniques and non-probability sampling techniques. For example, purposive, convenience, quota and snowball sampling. In this study, purposive sampling was used to draw the sample of teachers, as they possess specific knowledge and experience relevant to the research topic. Random sampling was applied to select learners, ensuring that every learner had an equal opportunity of being chosen, thereby minimizing selection bias and enhancing representativeness.

Purposive Sampling

According to Creswell (2014) purposive sampling involves deliberately choosing participants who can provide rich and relevant information about the phenomenon being studied. Leedy (2016) explains that this method is useful when researchers seek to gain insights from a targeted group that possesses particular expertise or experiences. Chiromo (2016) adds that purposive sampling allows researchers to focus on individuals who are most likely to help answer the

research questions effectively. Therefore, purposive sampling is a non-probability sampling technique used to select individuals based on specific characteristics or qualities that align with the study's objectives. In this case, the researcher draws all the 2 teachers teaching Physics at the school.

Random Sampling

Random sampling was used to select learners for the study. According to Kothari (2018) random sampling is a technique in which every member of the population has an equal chance of being selected. Creswell (2016) defines random sampling as a method of choosing participants in a way that ensures every individual in the population has the same probability of inclusion, reducing bias and increasing representativeness. Therefore, random sampling is a procedure that allows each member of a population to have an equal opportunity of being selected for a study. In this case, the process in this study involve preparing cards for the form 3A learners. The teacher prepared an equal matching number of cards to the boys in the class. The cards were of the same colour and shape. Some of the cards were marked, placed them in a box and asked the boys to line up and pick a card without looking. Only 6 cards were marked. Those who pick the six marked cards formed the sample. The same procedure was repeated separately for the girls to ensure fairness and equal chance of selection. Random sampling is advantageous because it reduces selection bias and gives a representative sample, but it can be time-consuming and requires careful preparation. The researcher prepared the cards in advance, supervised the selection process closely and ensured that all participants understand the procedure before sampling begins.

3.5Data Collection Procedures

Data collection procedures involve the systematic process of gathering information from participants to answer the research questions (Chiromo, 2017). In this study, data was collected from Physics teachers and learners using questionnaires, interviews and classroom observations. Questionnaires were administered to teachers to obtain their views on ICT integration, while interviews provided deeper insights into their experiences and challenges. Classroom observations were conducted to see how ICT tools are being used in real teaching and

learningsituations. The researcher first asked for permission from the school authorities and explained the purpose of the study to all participants to ensure cooperation. Questionnaires were distributed and collected within a specified time, interviews were scheduled individually, and observation sessions were carefully planned to cover different lessons. Random sampling was used to select learners, while purposive sampling guided the selection of teachers. All collected data was recorded accurately, kept confidential and organised systematically for analysis.

3.6 Data presentation and analysis

Yusuf and Balogun (2020) state that data presentation and analysis involve organizing and interpreting the collected information to draw meaningful conclusions. Quantitative data from questionnaires were presented using tables, charts, and graphs to show frequencies, percentages, and trends. Qualitative data from interviews and observations were summarized in descriptive narratives and thematic statements. Analysis focused on identifying patterns, relationships, and insights regarding the integration of ICT in teaching and learning Physics. Findings were linked to the study objectives to allow for valid conclusions and practical recommendations.

3.7 Reliability and Validity

According to Creswell (2014), trustworthiness in research is enhanced when multiple strategies are employed to ensure the credibility, dependability, and transferability of findings. To achieve this, the study employed triangulation, collecting data through questionnaires, interviews, and classroom observations, which allowed the researcher to verify information and enhance credibility. Cohen, Manion, and Morrison (2018) assert that triangulation reduces bias and strengthens confidence in the results by combining quantitative and qualitative evidence.

Leedy and Ormrod (2016) state that reliability is achieved through consistent application of research procedures. Therefore, questionnaires were administered using the same instructions, interviews followed a structured approach, and classroom observations used a checklist to maintain uniformity and reduce observer bias.

In this study, participants reviewed their interview transcripts to confirm the accuracy of their contributions. According to Merriam (2009), validity is enhanced by providing rich descriptions of the research context, which allows the findings to be transferable to similar environments. The

researcher also engaged in prolonged interaction with the school environment, allowing for authentic observation of classroom practices and reducing the risk of reactivity. Creswell and Poth (2018) state that peer debriefing helps ensure interpretations are grounded in evidence. In line with this, the researcher consulted supervisors to review and discuss data analysis and interpretations, thereby enhancing trustworthiness.

3.8 Ethical Issues

According to Bryman (2016), ethical research practices require obtaining informed consent, protecting participants' rights, and ensuring confidentiality. Permission was first obtained from the school authorities to conduct the study, and participants were informed about the purpose of the research, its objectives, and the intended use of the data. The participants were also assured that their involvement was voluntary and that they could withdraw at any time without any consequences.

Cohen, Manion, and Morrison (2018) assert that maintaining confidentiality and anonymity is critical in research to protect participants' identities. In this study, pseudonyms were used when reporting data, and no personal identifiers were recorded. According to Mayer (2015), ethical research demands that participants' dignity and well-being are respected. Therefore, interviews and classroom observations were conducted unobtrusively to minimize disruption and avoid discomfort.

Flick (2018) states that adherence to ethical principles such as respect, fairness, and integrity enhances the credibility and acceptability of research. In line with this, all collected data were stored securely and only accessed by the researcher. Consent forms were signed by participants to indicate informed agreement, and the research was conducted in accordance with ethical guidelines to ensure the protection of participants while maintaining academic integrity.

3.9 Chapter Summary

This chapter focused on the research methodology used to gather data. Research methodology refers to the process of collecting information and data to support decision-making. It encompassed the methods employed to gather data in order to ensure the reliability and validity of the research findings. The research methodology used in this study included the research

design, target population, sample and sampling procedures, research instruments, data collection procedures and data analysis procedures.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents, analyses, and interprets data collected from Physics teachers and learners regarding the integration of ICT tools in teaching and learning Physics in resource-constrained schools. The study employed questionnaires, interviews, and classroom observations to collect quantitative and qualitative data. Quantitative data were analysed using descriptive statistics such as frequencies and percentages, presented in tables, bar graphs, and pie charts. Qualitative data were analysed thematically to complement the quantitative findings, providing depth to the interpretation.

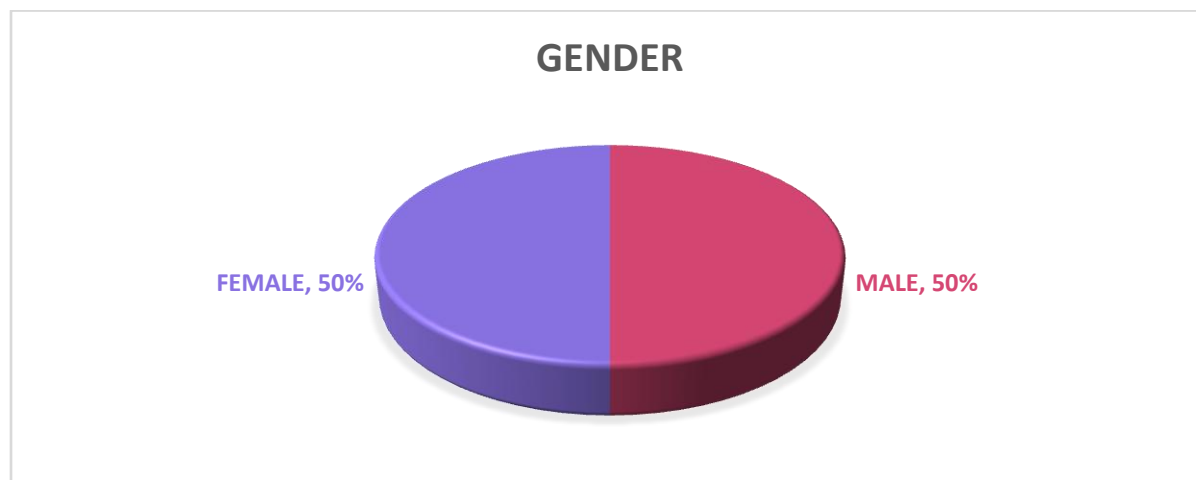
4.2 Bio Data of Respondents

4.2.1 Gender of Learners

A total of 12 learners participated in the study, consisting of 6 males and 6 females.

Gender	Frequency	Percentage
Male	6	50%
Female	6	50%
Total	12	100

Figure 4.1: Gender Distribution of Learners (Pie Chart)

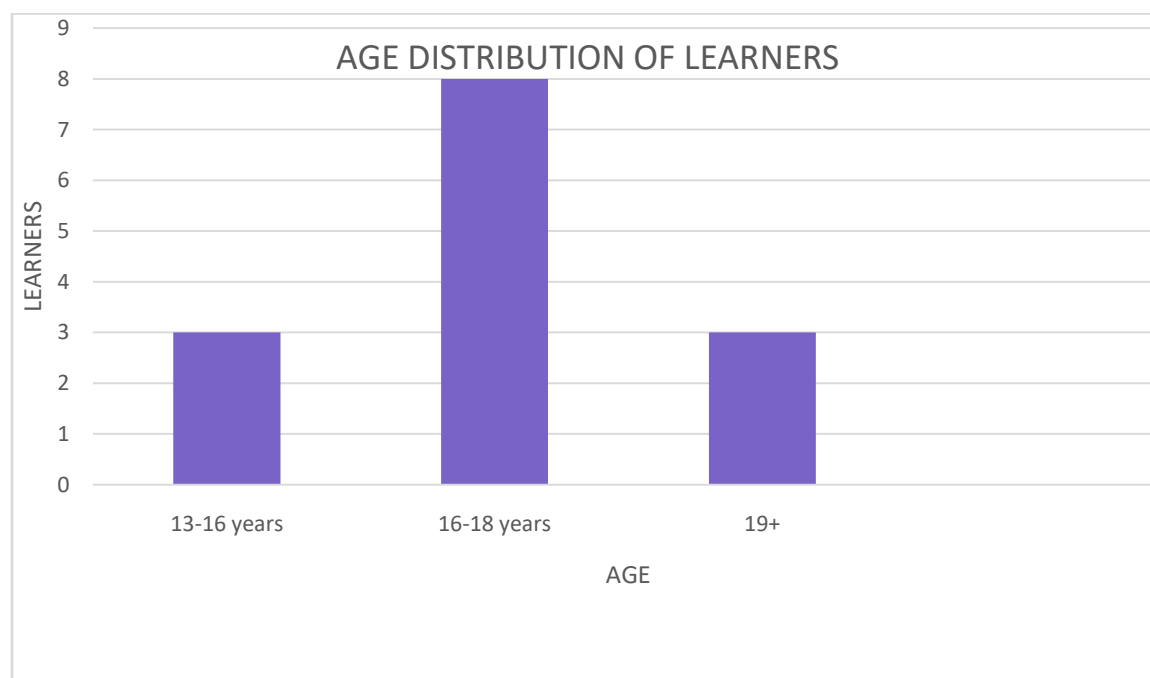


The sample comprised equal numbers of male and female learners, indicating balanced gender representation. This ensures that responses reflect perspectives from both genders, consistent with gender parity policies promoted in Zimbabwean secondary schools (MoPSE, 2023). According to Chikasha (2022), balanced gender representation is crucial for assessing ICT integration since both male and female learners may experience and respond to technology differently.

4.2.2 Age Distribution of Learners

AGE GROUP	FREQUENCY	PERCENTAGE
13-15 years	3	25%
16-18 years	8	67%
19+ years	1	8%
TOTAL	12	100

Figure 4.2: Age Distribution of Learners



Most learners (67%) were aged 16–18 years, the typical age for Form 3 students in Zimbabwe. According to Piaget’s theory of cognitive development, learners at this age are capable of

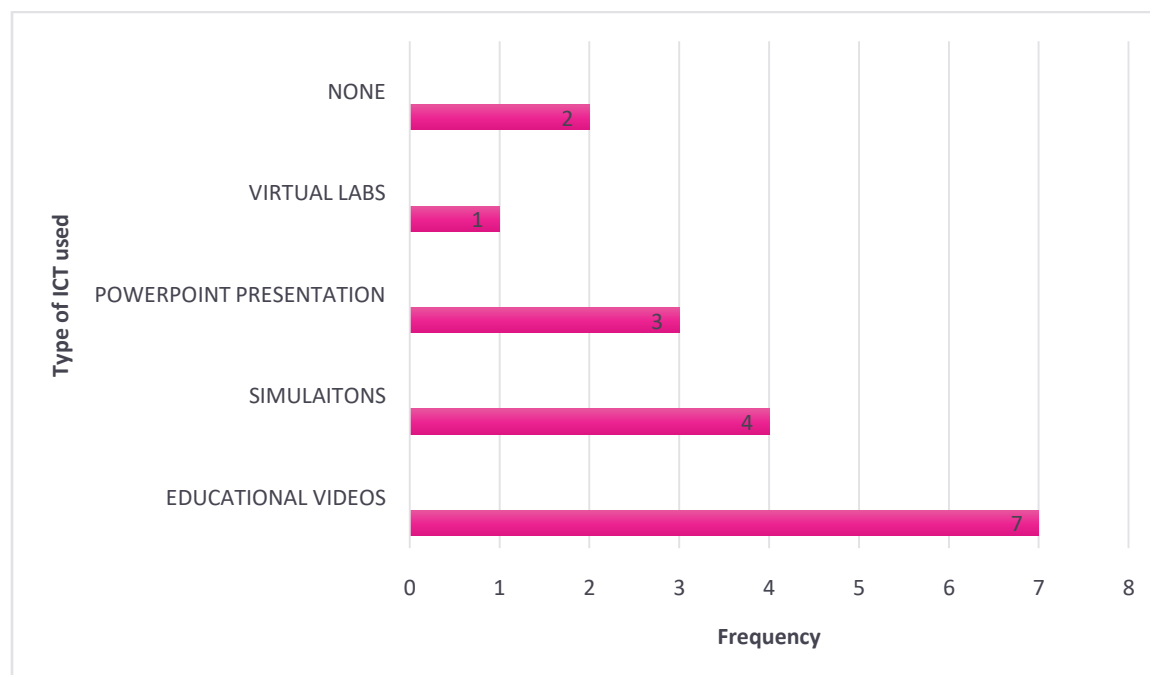
abstract reasoning and can comprehend complex Physics concepts (Chabaya & Gudhlanga, 2023). Mutambara (2021) states that learners in this age group can benefit significantly from ICT tools that make abstract phenomena tangible through visualisation.

4.3 Which ICT tools are currently available and accessible to teachers and learners for the teaching of Physics in resource-constrained schools?

4.3.1 Quantitative Findings

ICT TOOL	FREQUENCY	PERCENTAGE
Educational videos	7	58%
Simulations	4	33%
Power point presentations	3	25%
Virtual labs	1	8%
None	2	17%
TOTAL	12	100%

Figure 4.3: Types of ICT Tools Used in Physics Lessons (Bar Graph)



Educational videos were the most used tools (58%), followed by simulations (33%). Teachers confirmed using projectors and laptops when electricity was available, often showing downloaded YouTube videos on motion and energy. However, virtual labs were rarely used due to poor connectivity and outdated devices. This agrees with Dzvuke (2023) who found that ICT adoption in science subjects is constrained by infrastructural challenges in rural Zimbabwe.

4.3.2 Qualitative Findings

Teachers reported using projectors, laptops, and pre-downloaded videos to demonstrate Physics concepts. However, these tools were limited in availability, and electricity shortages often restricted usage. One teacher noted that “We use the projector for videos or PowerPoints when electricity is available, but most of the time we just explain using the chalkboard.”

Observations confirmed that in lessons with available ICT tools, learners were actively engaged and attentive, asking questions and discussing concepts, especially during video demonstrations

Interpretation

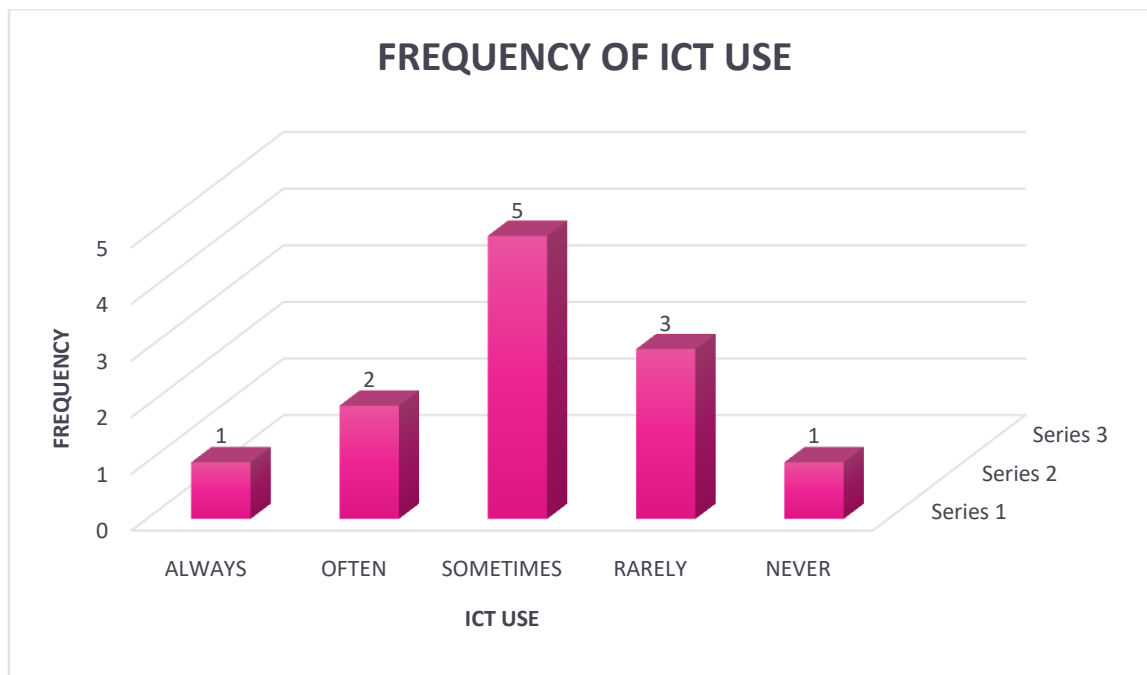
The findings show that while ICT tools are available, their accessibility is limited by infrastructure, electricity, and the number of devices. According to Ndawi (2020), availability alone does not ensure effective use; access, reliability, and teacher competence are equally critical. Chikasha (2022) states that rural schools often possess ICT tools but are unable to use them optimally due to power and resource constraints. This distinction between availability and practical accessibility is important when planning interventions to improve ICT integration.

4.4 How can ICT tools be effectively integrated to supplement the shortage of laboratories, apparatus, and textbooks in Physics teaching?

4.4.1 Frequency of ICT Use in Lessons.

FREQUENCY OF ICT USE	FREQUENCY	PERCENTAGE
Always	1	8%
Often	2	17%
Sometimes	5	42%
Rarely	3	25%
Never	1	8%
TOTAL	12	100%

Figure 4.4: Frequency of ICT Use in Physics Lessons (Column Chart)



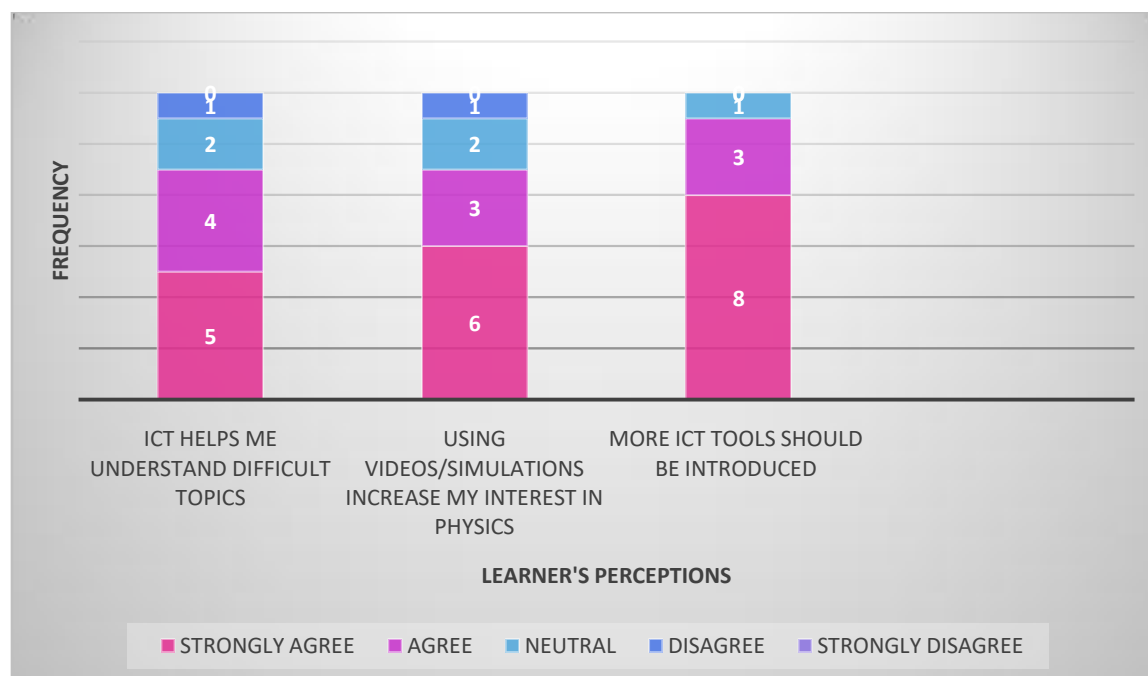
Findings reveal that only 25% of learners reported that ICT is used often in Physics lessons, while 42% said it is used sometimes. This indicates limited ICT integration, confirming Maphosa

(2022) who observed that ICT use in rural schools is irregular due to lack of equipment and unreliable electricity.

4.4.2 Learners' Perception of ICT Use

STATEMENT	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
ICT helps me understand topics	5	4	2	1	0
Using videos/simulations increase my interest in Physics	6	3	2	1	0
More ICT tools should be introduced	8	3	1	0	0

Figure 4.7: Learners' Perceptions of ICT Integration



A majority of learners agreed that ICT tools make Physics easier to understand and more interesting, demonstrating positive attitudes toward ICT integration. This resonates with

Marongwe (2021) who asserted that digital visuals improve comprehension of abstract scientific ideas. The enthusiasm displayed by learners highlights the motivational potential of ICT even in low-resource contexts.

4.4.2 Qualitative Findings

Classroom observations indicated that ICT integration, when applied, enhanced learner engagement and understanding. Teachers used projectors and videos to simulate experiments, particularly for abstract topics such as electricity and motion. One teacher explained:

“Even though we lack practical equipment, videos help learners visualise the experiments, making the lesson interactive.”

Interpretation

ICT tools serve as effective substitutes for laboratories, enabling learners to visualise abstract concepts and engage with the content actively. According to Mutambara (2021), simulations and videos can partially compensate for the absence of laboratory resources. Ndawi (2020) states that such ICT integration aligns with constructivist learning, where learners construct understanding through interaction with visual and interactive media.

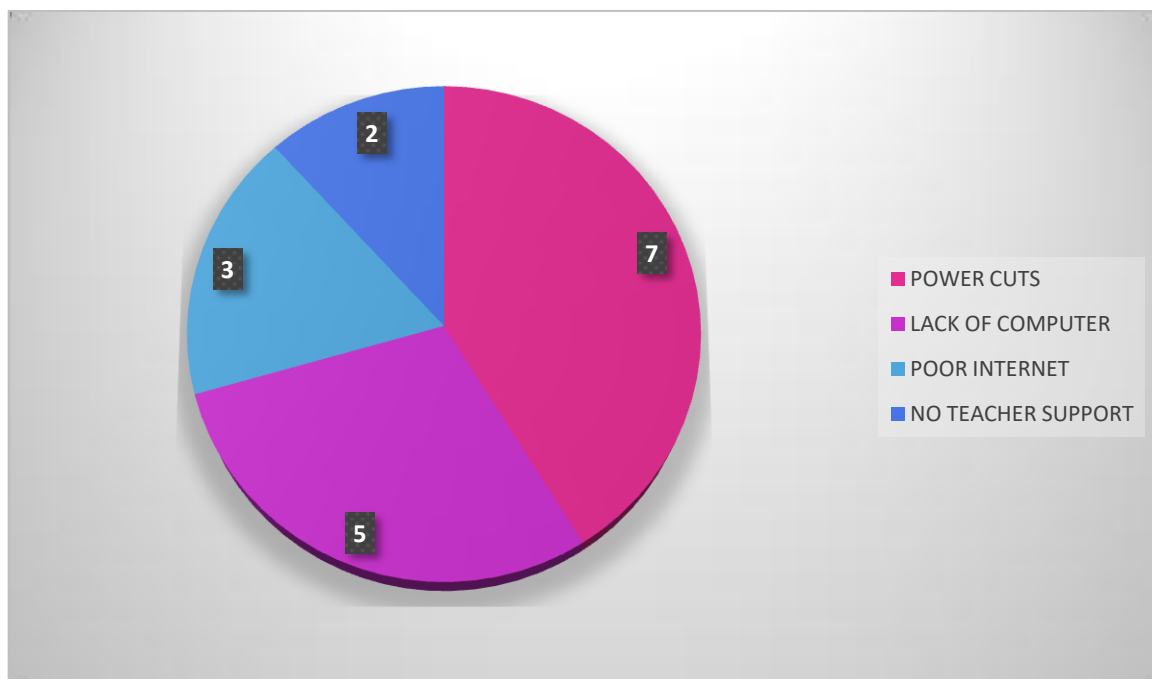
The findings suggest that ICT can bridge gaps caused by shortages of apparatus and textbooks, but its effectiveness is dependent on teacher skill, device availability, and electricity. Maphosa (2021) observes that consistent application of ICT, even in rural settings, leads to improved conceptual understanding and learner motivation.

4.5 What challenges do teachers and learners face in the integration of ICT in Physics education in resource-constrained schools?

4.5.1 Reported Challenges.

CHALLENGE	FREQUENCY	PERCENTAGE
Power cuts	7	58%
Lack of computers	5	42%
Poor internet	3	25%
No teacher support	2	17%

Figure 4.5: Challenges in Using ICT Tools (Pie Chart)



The most common challenge reported was frequent power cuts (58%), followed by lack of computers (42%). Teachers highlighted that even when devices are available, lessons are often disrupted by electricity cuts. These results agree with Mubika ((2022) who noted that unreliable electricity is a major barrier to e-learning in some schools in Zimbabwe. Additionally, poor internet connectivity (25%) and limited technical support. Poor internet and limited teacher support also affected ICT use (17%).

4.5.2 Qualitative Findings

Teachers reported limited ICT training and reliance on self-taught skills. They emphasized the difficulty of teaching with few devices and inconsistent electricity. One teacher stated,

“We need workshops on ICT integration. Most of us are willing but lack the expertise and equipment.”

Interpretation

The findings indicate that infrastructural and capacity-related factors are the primary obstacles to ICT integration. Chabaya and Gudhlanga (2023) state that rural schools often possess ICT tools but cannot utilise them effectively due to power and training limitations. Makoni (2020) observes that without consistent support, teachers cannot implement ICT pedagogically.

The study highlights that teacher readiness is high, but structural barriers such as unreliable electricity, limited hardware, and insufficient professional development hinder effective ICT adoption. According to UNESCO (2022), addressing these constraints is critical for achieving meaningful ICT integration in science education.

4.6 What strategies can be used to enhance the effective adoption and utilization of ICT tools in Physics teaching and learning?

Qualitative Findings

Teachers proposed several strategies:

- Provision of solar power backups to mitigate electricity disruptions.
- Increased number of ICT devices in schools.
- Professional development workshops for teachers.
- Peer mentoring among teachers to share ICT skills.

Interpretation

These strategies focus on improving infrastructure, capacity, and support systems. According to the Zimbabwe ICT Policy in Education (2016), sustainable ICT integration requires reliable

power, adequate devices, and teacher training. Maphosa (2021) states that context-sensitive strategies, such as offline video resources and peer learning, are effective in rural schools.

Implementing these strategies can enhance ICT adoption, improve learner engagement, and partially offset the lack of laboratory facilities, thereby supporting curriculum goals outlined in the Heritage-Based Curriculum Framework (2024–2030).

4.7 Discussion

The study sought to explore the extent to which ICT tools are available, accessible, and effectively integrated into the teaching and learning of Physics in resource-constrained schools. The discussion compares the findings with literature reviewed in Chapter 2 and interprets them in light of theories such as constructivism and multimedia learning.

The findings revealed that educational videos (58%) and simulations (33%) were the most accessible ICT tools, with teachers relying on projectors and laptops when electricity was available. This observation supports Dzvukeye (2023), who reported that most rural schools depend on offline digital materials such as pre-downloaded videos due to poor internet connectivity. Similarly, Nyoni and Mupfema (2021) found that teachers in Manicaland Province frequently use downloaded multimedia resources to demonstrate Physics concepts in the absence of laboratory equipment. This confirms the argument advanced by Ndawo (2020) that availability of ICT tools alone does not ensure accessibility; reliable power, connectivity, and user competence are equally essential for effective utilization.

Balanced gender participation in this study also reflects the Ministry of Primary and Secondary Education's (2023) emphasis on equitable access to ICT-enhanced learning. As Chikasha (2022) observed, gender balance is vital because male and female learners may interact differently with technology, and parity helps capture diverse learning experiences. Such inclusion supports national education goals of equality and digital literacy for all learners.

In addition to availability, this study found that ICT tools such as videos and simulations served as effective substitutes for laboratories and apparatus shortages. Learners confirmed that visual and interactive tools made Physics easier to understand and more engaging. This finding aligns

with constructivist and multimedia learning theories advanced by Piaget (1971) and Vygotsky (1978), which emphasize that learners construct knowledge through active engagement with visual and experiential stimuli. Mutambara (2021) also demonstrated that simulations enable learners to visualize abstract scientific phenomena that would otherwise be difficult to grasp. Similarly, Marongwe (2021) noted that ICT-enhanced lessons improve comprehension and retention of Physics concepts such as electricity and magnetism.

The study further observed increased learner motivation and participation in ICT-supported lessons, consistent with Maphosa's (2022) assertion that visual and interactive media sustain learner attention and enthusiasm. UNESCO (2022) also supports this finding, affirming that ICT can compensate for the absence of physical laboratories by allowing learners to engage with virtual experiments and conceptual simulations. However, the benefits of ICT remain conditional upon adequate teacher competence and technical support, as emphasized by Chabaya and Gudhlanga (2023).

Despite these benefits, the study revealed several challenges hindering ICT integration. The most significant were frequent power cuts (58%), inadequate computers (42%), and poor internet connectivity (25%). These challenges echo those reported by Mubika (2022) and Makoni (2023), who identified unreliable electricity and obsolete hardware as major obstacles to ICT adoption in Zimbabwean rural schools. Similar findings were observed in other Southern African contexts; Chisango and Maphosa (2022) noted that infrastructural limitations across rural Zambia and South Africa produce the same digital divide patterns found in Zimbabwe. Furthermore, teachers in this study indicated a lack of technical support and limited professional development, relying mostly on self-taught skills. Ndawi (2020) and UNESCO (2022) similarly reported that absence of structured training undermines teachers' ability to integrate ICT pedagogically.

Teachers proposed several strategies to overcome these challenges, including the use of solar power backups to address electricity shortages, the procurement of more ICT devices, and the provision of professional development workshops. These recommendations align with Maphosa's (2021) advocacy for renewable energy in rural schools and the Zimbabwe ICT Policy in Education (2016), which calls for continuous teacher training and localized innovation. Peer mentoring among teachers, as suggested by participants, also reflects Chabaya and Gudhlanga's

(2023) model of collaborative skill-sharing, which strengthens teacher confidence and sustainability of ICT initiatives.

Collectively, these findings reinforce the view that while ICT tools have transformative potential in Physics education, their full impact is constrained by systemic factors such as infrastructure, training, and technical support. The convergence between this study's findings and previous research confirms that the digital divide in rural schools is not primarily due to teacher reluctance but to structural inequalities. Addressing these challenges through solar power systems, capacity-building programs, and strategic partnerships can promote sustainable ICT adoption and improve learning outcomes in Physics. Such interventions are consistent with the Heritage-Based Curriculum Framework (2024–2030), which emphasizes innovation, inclusivity, and context-sensitive application of technology in education.

4.8Chapter Summary

This chapter presented and analysed data collected from teachers and learners regarding the integration of ICT tools in teaching and learning Physics in resource-constrained schools. Findings revealed that educational videos and simulations were the most used ICT tools, though their effectiveness was limited by infrastructural challenges such as unreliable electricity and a shortage of computers. Despite these challenges, ICT was shown to enhance learners' understanding and engagement, particularly when used to visualise abstract Physics concepts. The study further established that while teachers were willing to use ICT, their efforts were constrained by inadequate training, poor connectivity, and a lack of technical support. Nonetheless, their commitment and learners' enthusiasm indicated strong potential for ICT integration if support systems are strengthened. Teachers suggested solutions such as solar power backups, increased ICT devices, and regular professional development.

Overall, the chapter demonstrated that ICT can significantly enhance Physics instruction in rural schools by compensating for limited laboratory resources. However, sustainable adoption depends on addressing infrastructural and capacity-related challenges. The next chapter will present conclusions and recommendations drawn from these findings.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study, draws conclusions, and proposes recommendations based on the findings regarding ICT integration in the teaching and learning of Physics in resource-constrained schools. It focuses on how the research objectives were met, examines challenges encountered, and suggests practical measures to enhance ICT adoption in Physics education. According to UNESCO (2022), effective ICT integration requires attention to infrastructure, teacher competence, and policy support, making this study relevant in addressing the digital divide in rural Zimbabwean schools.

5.2 Summary of the Project

Chapter 1: Introduction

The first chapter provided an overview of the study by outlining the background, problem statement, purpose, and significance of exploring ICT integration in Physics teaching within resource-constrained schools. It noted that most rural secondary schools in Zimbabwe face persistent challenges such as limited laboratory equipment and outdated teaching resources. The study therefore sought to investigate how ICT tools could be effectively used to enhance learning in such contexts. The chapter also presented the research objectives, questions, and justification, aligning the study with national efforts to promote digital learning under the Heritage-Based Curriculum Framework (2024–2030).

Chapter 2: Literature Review

Chapter two reviewed theoretical and empirical literature related to ICT use in science and Physics education. The review was guided by the constructivist learning theory, which emphasises that learners construct knowledge through interaction and engagement with technological tools. It discussed how ICT can improve learner participation and understanding of abstract scientific concepts. The chapter also identified common barriers to ICT integration, including insufficient infrastructure, lack of teacher training, and limited administrative support. These gaps in the literature justified the need for this study, particularly in the context of rural Zimbabwean schools where ICT implementation remains inconsistent.

Chapter 3: Research Methodology

The third chapter explained the research design and methods used to collect and analyse data. A mixed-methods approach was employed, combining quantitative and qualitative techniques to obtain a comprehensive understanding of the issue. Data were gathered through questionnaires, interviews, and classroom observations involving Physics teachers and learners in a secondary school in Zvimba. The chapter also outlined the population, sampling techniques, data analysis methods, and ethical considerations. To ensure validity and reliability, strategies such as triangulation and pilot testing were applied. This approach allowed the researcher to capture both statistical data and the lived experiences of participants.

Chapter 4: Data Presentation, Analysis and Interpretation

Chapter four presented and discussed the findings from the study. Results showed that ICT tools such as projectors, educational videos, and computer simulations were the most commonly used resources in Physics lessons. These tools helped learners to visualise difficult concepts such as electricity, motion, and energy. Teachers reported that ICT made lessons more interactive and improved learners' motivation and understanding. However, several challenges were also noted, including unreliable electricity, limited ICT hardware, and insufficient teacher training. Despite these obstacles, learners generally perceived ICT-supported lessons as enjoyable and beneficial. The findings confirmed that ICT can serve as an effective alternative to traditional laboratory experiments in resource-constrained settings.

Chapter 5: Summary, Conclusions and Recommendations

The fifth chapter brought together all the major insights from the preceding chapters. It summarised the study, presented the key conclusions, and suggested practical recommendations for improving ICT integration in Physics education. The chapter emphasised that ICT has great potential to enhance both teaching and learning processes in rural secondary schools, provided that infrastructural and human resource challenges are addressed.

5.3 Constraints of the Study

Despite the valuable findings, the study encountered several challenges that affected data collection and analysis. Access to remote schools was limited by transport difficulties,

occasionally causing delays in fieldwork. Additionally, some participants were unavailable or could only provide limited responses due to tight school schedules and overlapping academic activities, such as examinations.

Systemic and infrastructural limitations within schools also posed challenges. According to Mubika (2022), frequent power outages, poor internet connectivity, and a shortage of functional computers affected both classroom ICT use and the researcher's observations. Teachers reported limited professional development in ICT, which sometimes constrained their ability to implement digital learning effectively (Dzvuke, 2023).

Nonetheless, the study successfully achieved its objectives and generated reliable insights into the role of ICT in Physics education. These constraints highlight the broader systemic challenges in rural schools and underscore the need for infrastructural improvements and teacher capacity-building to support effective ICT integration (Maphosa, 2021).

5.4 Conclusions

The study concludes that ICT has significant potential to enhance the teaching and learning of Physics in resource-constrained schools. It is stated that availability of technology alone is insufficient; effective use depends on teacher competence, infrastructural support, and policy guidance (Chikasha, 2022).

ICT tools such as simulations, animations, and educational videos can serve as substitutes for laboratory resources by providing interactive and visual learning experiences. Research by Mutambara (2021) highlights that these tools allow learners to visualise abstract scientific concepts that would otherwise be difficult to comprehend. This finding aligns with constructivist learning theory, which posits that learners construct knowledge through active engagement and interaction with learning materials (Maphosa, 2021).

Teacher competence emerged as a critical factor. According to Chabaya and Gudhlanga (2023), teachers who are confident and trained in ICT are more likely to integrate technology effectively, while those lacking professional development struggle to do so. Furthermore, infrastructural and

systemic challenges—including unreliable electricity, insufficient hardware, and limited technical support—remain major barriers to consistent ICT use (Mubika, 2022).

Finally, sustainable ICT integration requires a collaborative approach involving government, schools, communities, and other stakeholders. UNESCO (2022) states that coordinated support, continuous monitoring, and policy guidance are essential to ensure equitable access and effective use of ICT in rural schools.

5.5 Recommendations

Based on the study's findings and conclusions, several strategies are recommended to strengthen ICT integration in Physics education. According to Dzvuke (2023), schools should prioritise reliable energy sources, such as solar power systems, to mitigate frequent electricity outages and enable uninterrupted ICT-based lessons.

It is also recommended that schools be equipped with sufficient ICT resources, including functional computers, projectors, and offline digital learning materials. Research by Mubika (2022) suggests that offline platforms, pre-recorded simulations, and educational videos are particularly effective in rural schools with limited internet connectivity.

Improving teacher competence is essential. According to Maphosa (2021), ongoing professional development and integration of ICT modules into pre-service teacher education can enhance teachers' ability to use technology pedagogically. Peer mentoring within schools can further strengthen teacher confidence and facilitate knowledge sharing (Chabaya & Gudhlanga, 2023).

Partnerships between schools, communities, and external stakeholders are also recommended. Chikasha (2022) states that involvement of School Development Committees, alumni associations, and local businesses can support ICT initiatives through provision of resources, funding, or technical assistance, ensuring sustainability.

Finally, national policy frameworks should provide monitoring and evaluation mechanisms to ensure that ICT integration aligns with curriculum objectives and promotes equitable access across rural and urban schools (UNESCO, 2022). Implementing these recommendations will enhance learner engagement, improve understanding of Physics concepts, and foster digital literacy skills among students.

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APPENDICES

Appendix 1: Questionnaire for Students

Project Title: Integration of ICT Tools in Teaching and Learning Physics in Resource-Constrained Schools

Researcher: Makaure Aquilina Batsirai

Institution: Bindura University of Science Education

Purpose: This questionnaire seeks to collect information from students about their experiences in learning Physics using ICT tools such as computers, projectors, simulations, and educational videos. Your participation is voluntary, and all responses will be treated confidentially. Do not write your name.

Section A: Demographic Information

1. Gender: ☐ Male ☐ Female

2. Age: ☐ 13–15 ☐ 16–18 ☐ 19+

3. Form: ☐ Form 3 ☐ Form 4

4. How long have you been learning Physics?

☐ Less than 1 year ☐ 1–2 years ☐ 3 years or more

Section B: Learning Physics without Laboratories or Equipment

1. What challenges do you face when learning Physics without a proper laboratory?

☐ It is difficult to see experiments

☐ I do not understand some topics

☐ Lessons are boring

☐ Other: _____

2. How does the lack of science equipment affect your learning?

- ☐ I fail to understand experiments
- ☐ I rely too much on theory
- ☐ My performance is low
- ☐ Other: _____

3. Please indicate your level of agreement:

a) Lack of laboratories makes it difficult to understand Physics.

- ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

b) Lack of textbooks affects how I prepare for tests and exams.

- ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section C: Use of ICT Tools in Learning Physics

1. How often do your teachers use ICT tools (e.g., projectors, computers, videos, simulations) in Physics lessons?

- ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

2. Which ICT tools have you used during Physics lessons?

- ☐ Simulations ☐ Educational videos ☐ Virtual labs ☐ PowerPoint presentations ☐ None

3. ICT tools make Physics lessons:

- ☐ More interesting ☐ Easier to understand ☐ Difficult to follow ☐ No change

4. Please indicate your level of agreement:

a) ICT tools help me understand difficult topics.

- ☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

b) Using videos and simulations increases my interest in Physics.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Section D: Challenges and Suggestions

1. What challenges do you face when using ICT tools in Physics lessons?

☐ Lack of computers ☐ Power cuts ☐ Poor internet connection ☐ No teacher support

Other: _____

2. What can your school do to help you learn Physics better using ICT tools?

☐ Provide more ICT equipment

☐ Train teachers to use ICT

☐ Allow students to use ICT in study time

☐ Other: _____

3. Please indicate your agreement:

a) More ICT tools should be introduced in Physics lessons.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

b) ICT helps me perform better in Physics tests and exams.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Thank you for your participation!

APPENDIX 2: Interview Guide for Teachers

My name is Makaure Aquilina. I am a student at Bindura University of Science. I am currently studying the Bachelor of Science Honors Degree in Physics. As part of my studies I am expected to produce a completed research in partial fulfillment of the degree program. As such, I am studying the integration of ICT tools in teaching and learning Physics in resource-constrained schools. Against this background, I am therefore, kindly requesting you to take part in the study by taking part in this interview. Please note that this is purely for study purposes only. All ethical considerations are observed. Your name will not be required. Thank you for your participation.

Interview Questions

Section A: Background Information

1. How long have you been teaching Physics?
2. What is your highest professional qualification?
3. Have you received any training related to ICT integration in education?

Section B: Teaching Physics in Resource-Constrained Schools

4. What challenges do you face when teaching Physics without adequate laboratory facilities and equipment?
5. How do these challenges affect the quality of teaching and students' understanding?
6. What strategies have you used to overcome the lack of laboratory resources?

Section C: Use of ICT Tools in Teaching Physics

7. What ICT tools do you currently use in your Physics lessons (e.g., computers, projectors, simulations, videos)?
8. How do ICT tools help in explaining difficult Physics concepts?

9. How do students respond when ICT tools are used during lessons?

10. How has the use of ICT affected student performance and engagement in Physics?

Section D: Challenges and Support for ICT Integration

11. What challenges do you face when using ICT tools (e.g., power supply, limited devices, lack of training)?

12. What support does your school provide to facilitate ICT use in teaching?

13. In your view, what measures should be taken to promote effective ICT integration in Physics teaching?

Section E: Teacher Development and Policy Recommendations

14. How can teachers be encouraged or motivated to use ICT tools more effectively?

15. What kind of training or professional development would help you integrate ICT better?

16. What policies or initiatives should be introduced at school or ministry level to enhance ICT-based Physics education?

Conclusion

Is there anything else you would like to add regarding the use of ICT in teaching Physics?

Thank you for your participation!

Appendix 3: Classroom observation guide

Observation of ICT Integration in Physics Lessons

Observer: _____

Date: _____

Class/Form: _____

Teacher: _____

Purpose: To observe how ICT tools are being used to enhance teaching and learning of Physics in resource-constrained classrooms.

Observation Checklist

Please tick (✓) the appropriate box or write notes where necessary.

Check Item	Yes	No	Comments
1. The teacher uses ICT tools (e.g., computer, projector, simulation, educational video) during the lesson.	☐	☐	
2. Learners are actively engaged when ICT tools are used.	☐	☐	
3. ICT tools are used to demonstrate or explain Physics concepts clearly.	☐	☐	
4. Learners are given opportunities to interact with ICT tools (hands-on activities, exercises).	☐	☐	
5. The teacher shows confidence and competence in operating ICT tools.	☐	☐	
6. ICT use helps learners understand difficult concepts better.	☐	☐	
7. The lesson integrates ICT tools with other teaching methods (discussion, experiments, textbook use).	☐	☐	
8. Any challenges observed during ICT use (e.g., technical issues, lack of resources).	☐	☐	

Observer Signature: _____

APPENDIX 4

ETHICS CLEARANCE LETTER



P BAG 1020

BINDURA

ZIMBABWE

TEL: 0271-7531 ext. 1038

Fax: 263-71-7616

BINDURA UNIVERSITY OF SCIENCE EDUCATION

Name: Aquilina Batsirai Makaure

Registration Number: B240009A

Part: 2.2

Programme: HBScEd (Physics)

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

The student is required to undertake research and thereafter present a Research Project in partial fulfillment of the requirements for the HBScEd (Physics) degree Programme. The research topic is: INTERGRATION OF ICT TOOLS IN TEACHING AND LEARNING OF PHYSICS IN RESOURCE –CONSTRAINED SCHOOLS

In this regard, the Department kindly requests your permission to allow the student to carry out her research in your institution.

Your cooperation and assistance are greatly appreciated.

Yours faithfully,

.....

Dr. Ndemo

Chairperson – SAMED