BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

AN ASSESSMENT ON THE INTEGRATION OF ICT IN THE TEACHING AND LEARNING OF PHYSICS.

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(B1747820)

A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

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APPROVAL FORM

TITLE OF RESEARCH STUDY

AN ASSESSMENT ON THE INTEGRATION OF ICT IN THE TEACHING AND LEARNING OF PHYSICS.

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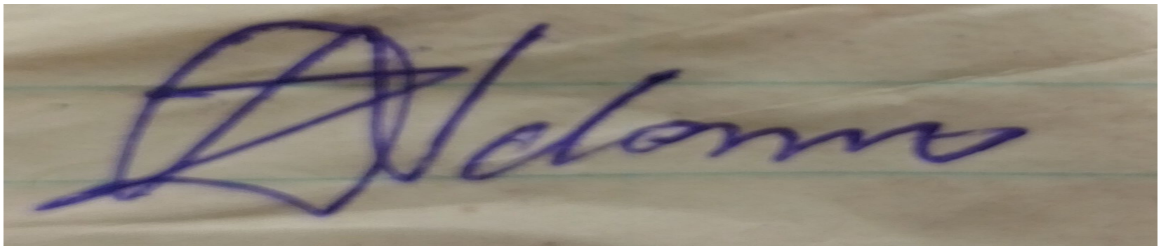

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AUTHOR'S DECLARATION

I Tendai Terrence Murombedzi , declare that the assessment on the integration of ICT in the teaching and learning of physics, titled [AN ASSESSMENT ON THE INTEGRATION OF ICT IN THE TEACHING AND LEARNING OF PHYSICS], is my original work. I have conducted this assessment independently and have acknowledged all the sources used in the assessment through proper citations and references.

I declare that the information and data presented in this assessment are accurate and reliable to the best of my knowledge. Any opinions or views expressed in this assessment are solely mine and do not reflect the opinions of any organization or institution.

I further declare that this assessment has not been submitted in whole or in part for any other degree, diploma, or qualification. I understand the consequences of plagiarism and certify that all the content in this assessment is original and does not infringe upon the intellectual property rights of others.

Date: 4 June 2024

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Supervisor's name: Dr Nicholas, Zezekwa

Signature………………………………………………………………………… Date: June 2024

DEDICATION:

I dedicate this research project to my beloved family, especially my mother and my siblings, Takunda and Taona Murombedzi. Throughout my academic journey, they have provided unwavering support, encouragement, and love during both challenging and joyous times. Their belief in my abilities and their constant presence in my life has been instrumental in my accomplishments.

I also extend my dedication to my future family, who will undoubtedly play a significant role in my continued growth and success. Their anticipated support and understanding will be invaluable as I navigate new opportunities and challenges in the future.

To my family, you have been my pillars of strength and my greatest source of motivation. Your unwavering support, sacrifices, and belief in me have fueled my determination to pursue this research project and excel in my academic endeavours. I am forever grateful for your love, encouragement, and the countless ways in which you have shaped my life.

This dedication is a token of my deep appreciation and love for my family, both present and future. May we continue to share many more moments of joy, success, and togetherness as we journey through life.

With heartfelt gratitude,

Murombedzi T

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I am deeply indebted to my family and friends for their unwavering support, encouragement, and understanding. Their love, belief in my abilities, and constant presence have been a source of strength and motivation. I am forever grateful for their patience, understanding, and sacrifices they have made throughout my academic journey. Their unwavering support has been a driving force behind my accomplishments.

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To all those who have played a part, whether big or small, in the completion of this project, I extend my heartfelt appreciation. Your support, encouragement, and contributions have been invaluable. May God bless each one of you.

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Abstract:

This assessment explores the integration of Information and Communication Technology (ICT) in the teaching and learning of physics. The research aims to evaluate the impact of ICT integration in physics education and examine its benefits and challenges. The research method employed is qualitative, utilizing a multiple exploratory case study design. The research instruments include student questionnaires, teacher interview schedules, and classroom observations. The assessment begins by providing an overview of common ICT tools used in physics education, such as simulations, virtual laboratories, multimedia presentations, and online resources. It highlights the advantages of integrating ICT in physics teaching, including promoting active learning, facilitating conceptual understanding, and enabling personalized learning experiences. The reviewed studies indicate that incorporating ICT positively impacts student engagement, motivation, and achievement. Additionally, ICT tools facilitate inquiry-based learning, foster critical thinking skills, and provide collaboration opportunities.

The assessment also addresses the potential challenges faced by educators when implementing ICT tools, such as technical issues, accessibility concerns, and the need for adequate training and support. It emphasizes the importance of pedagogical strategies that effectively integrate ICT tools and highlights the significance of continuous professional development to enhance educators' digital literacy skills. Furthermore, the assessment emphasizes the need to create a supportive environment that ensures equitable access to ICT resources for all students.

This assessment reveals that integrating ICT in the teaching and learning of physics offers numerous benefits, including enhanced student engagement, conceptual understanding, and collaborative learning experiences. However, it acknowledges the challenges faced by educators and emphasizes the importance of addressing them through appropriate training and support. The major recommendations include incorporating effective pedagogical strategies, providing continuous professional development for educators, and promoting equitable access to ICT resources. By considering the findings and recommendations of this assessment, educators can make informed decisions about effectively integrating ICT tools in physics education to improve student learning outcomes.

LIST OF ABBREVIATIONS AND ACRONYMS

ICT:	Information and Communication Technology
UNICEF:	United Nations International Children's Emergency Fund.
STEM:	Science, Technology, Engineering, and Mathematics.
TPACK:	Technological Pedagogical Content Knowledge.
CK:	Content Knowledge.
PK:	Pedagogical Knowledge
TK:	Technological Knowledge..
ZIMSEC:	Zimbabwe Schools Examinations Council.

Chapter One: INTRODUCTION

1.1 Introduction to the Study

In the rapidly evolving education landscape, integrating Information and Communication Technology (ICT) has become a critical factor in shaping teaching and learning practices. As educators strive to enhance pedagogical approaches, understanding the impact of ICT on specific subjects, such as physics, is essential. In recent years, integrating Information and Communication Technology (ICT) in teaching and learning has gained significant attention in education. With the rapid advancement of technology, educators are exploring innovative ways to enhance the learning experience and improve student outcomes. There has been a rapid advancement in Information and Communication Technology (ICT) that has revolutionized various aspects of our lives, including education. The integration of ICT in the teaching and learning process has become a topic of great interest and concern among educators, researchers, and policymakers. The integration of Information and Communication Technology (ICT) in education has gained significant attention. ICT tools have transformed the teaching and learning processes, providing new opportunities for educators and students alike. This chapter delves into the assessment of ICT integration in the teaching and learning of physics at the ordinary level.

The rest of this chapter is organized as follows: Section 1.2 provides the background of the study, explaining the context and rationale for the research topic. Section 1.3 presents the statement of the problem, identifying the main research gap and the specific problem that this study aims to address. Section 1.4 formulates the research questions that guide the inquiry and the objectives that the study intends to achieve. Section 1.5 states the study's purpose, clarifying the research's scope and focus. Section 1.6 discusses the assumptions underlying the qualitative research approach adopted for this study. Section 1.7 highlights the significance of the study, outlining the expected contributions and implications of the research findings. Section 1.8 defines the delimitations of the study, specifying the boundaries and limitations of the research. Section 1.9 explains the limitations of the study, acknowledging the potential weaknesses and challenges of the research. Section 1.10 defines terms, clarifying the meaning and usage of key concepts and terms in the study. Section 1.11 describes the organization of the study, summarizing the main contents and structure of each chapter. Section 1.12 concludes the chapter and provides a transition to the next chapter

1.2 Background of the Study

Physics education is pivotal in equipping students with scientific knowledge and critical thinking skills. Physics is a fundamental subject that plays a crucial role in shaping our understanding of the natural world Adedokun-Shittu and Shittu (2015). Physics education is crucial in equipping students with scientific knowledge and critical thinking skills. Traditionally, physics classrooms relied on lectures, textbooks, chalkboards, and physical experiments. However, traditional teaching methods have often struggled to capture students' interest and enhance their understanding of complex physics concepts, traditional teaching methods also fail to fully engage students and make the subject matter more accessible and relatable Mulhall (2019). Physics is the **basic physical science** that investigates the structure of matter and the interactions between its fundamental constituents within the observable universe. It encompasses both macroscopic and sub-microscopic phenomena. In essence, physics seeks to uncover the underlying principles that govern nature, expressed with precision through the language of mathematics. It's the science of matter, motion, and energy (Argaw et al., 2016).

Physics branches out into several distinct areas, each focusing on specific aspects of the physical world. Let's explore some of these branches:
Classical Mechanics: Also known as **Newtonian mechanics**, it deals with forces acting upon bodies. Subfields include statics (study of objects at rest), dynamics (study of motion), and kinematics (description of motion). Mulhall & Daniel (2019) **Thermodynamics** studies temperature, pressure, volume, and energy transfer. It emerged from the quest to improve early steam engines. **Electromagnetism**: This branch investigates electrons, electric media, magnets, magnetic fields, and light interactions. **Optics**: Optics explores light, its properties, and its interactions with matter. Topics include reflection, refraction, diffraction, and polarization. **Nuclear Physics**: Focuses on the nucleus of atoms, nuclear physics deals with nuclear reactions, radioactivity, and particle accelerators (Owen et al, 2018).

Physics is often called the **fundamental science** because it underpins other scientific disciplines. Here are some connections **Chemistry**: Chemistry relies on physics principles, especially in understanding atomic and molecular behaviour. **Geology**: Geophysics uses physics to explore Earth's interior, seismic waves, and magnetic fields. (Linder et al., 2014). **Engineering**: Physics informs engineering disciplines, from electrical circuits to structural mechanics. **Medicine**: Biophysics contributes to medical imaging techniques and understanding of biological processes. **Environmental Science**: Physics concepts help explain climate, ocean currents, and natural phenomena.

The digital era has ushered in new possibilities. The infusion of ICT tools—ranging from interactive simulations to online resources and resources like computers, and educational software —has transformed the way physics concepts are conveyed. With the emergence of ICT tools and resources, there is an opportunity to enhance the teaching and learning experience in physics classrooms (Kipyator, 2017). The use of ICT can facilitate interactive learning, visualization of complex concepts, and access to a vast array of educational resources, the rapid advancement of technology, and the integration of ICT in physics education have shown promise in addressing these challenges Exploring this shift in educational paradigms provides valuable insights for educators, policymakers, and curriculum developers. The integration of ICT tools has the potential to revolutionize physics education, making it more interactive, engaging, and effective.

In Zimbabwe, the integration of **(ICT)** into physics education faces several challenges and barriers. Let's explore some of these factors: **Lack of Frameworks**: There are no well-defined frameworks in place to guide the seamless integration of ICTs into teaching and learning. Education (Bin Noordan & Md. Yunus, 2022). Curriculum **Review**: The existing curriculum needs a thorough review and overhaul to accommodate ICT integration effectively. Policies. **Teacher Readiness and Training**: Teachers often struggle with using technology in the classroom. **Access to Technology**: Limited access to necessary technologies can be a significant barrier. Schools need adequate infrastructure, devices, and reliable internet connectivity to facilitate ICT integration. Challenge. Attitudes **and Beliefs**: Teachers' personal attitudes, self-confidence, and beliefs about integrating digital technologies play a vital role. Linder (2014).

Abiribi and Jekayinka (2013) view education as an instrument for the development of any nation, hence a nation must put a lot of resources into it if it has to benefit meaningfully. This is true for Zimbabwe, the government, voluntary organizations, individuals and schools are channelling a lot of resources and funding towards science education to achieve success in this sector. In 2014 the Government Educational Transition Fund through UNICEF provided all Zimbabwean secondary schools with science kits and science textbooks for use in the teaching and learning of sciences (UNICEF Report, 2014). The government introduced a Science, Technology, Engineering and Mathematics (STEM) policy which encourages the teaching and learning of science subjects (Physics, chemistry, computer sciences, food science, mathematics and biology) by providing free education to students who take sciences at Advanced level (Government of Zimbabwe STEM Report, 2016). All this shows that a lot of effort is being put into encouraging the teaching and learning of sciences in schools. According to Bolu-steve and Sanni (2013), parents devote a lot of resources to their children's education because they believe that good academic performance will provide a stable future for them. The success of a country comes from its citizens, the skills they acquire from education and how best they can apply these acquired skills for the development of their country. Poor performance by students in science subjects led to the underdevelopment of a nation since the country could not be able to produce its experts in the field of science and as a result, would depend on hiring experts from other countries in areas it would have produced its experts.

ICT has the potential to enhance the teaching and learning experience in physics classrooms by facilitating interactive learning, visualization of complex concepts, and providing access to a vast array of educational resources. Interactive simulations, online resources, educational software, and other ICT tools can transform the way physics concepts are conveyed and make the subject matter more accessible and relatable for students Adedokun et al (2015). According to Ghavifekr (2015), ICT tools provide opportunities for students to actively engage with the subject, explore phenomena, and develop a deeper conceptual understanding. Enhanced Visualization: ICT allows students to visualize abstract physics concepts through simulations, animations, and interactive models. This visual representation enables students to grasp complex ideas more effectively and develop a concrete understanding of physical phenomena. Active Learning: Khan (2012) postulates that ICT provides opportunities for active learning, where students can explore and manipulate variables, conduct virtual experiments, and observe the outcomes. This hands-on approach promotes critical thinking, problem-solving skills, and a deeper engagement with the subject matter. Access to Educational Resources: The integration of ICT in physics learning provides students with access to a vast array of educational resources, such as online textbooks, videos, articles, and interactive websites. These resources expand their learning beyond the limitations of traditional textbooks and classroom materials, allowing them to explore diverse perspectives and gain a broader understanding of physics concepts Kibirige (2014). Research also shows that, Personalized Learning: ICT tools can be tailored to students' individual needs and learning styles, allowing for personalized learning experiences. Adaptive technologies, online quizzes, and interactive tutorials can provide immediate feedback, identify areas of difficulty, and offer targeted interventions, thereby promoting self-paced learning and addressing individual learning gaps. Linder (2014) suggests Collaboration and Communication: ICT facilitates collaborative learning environments, where students can engage in discussions, share ideas, and work on projects together. Online platforms, discussion forums, and video conferencing tools enable students to collaborate beyond the confines of the classroom, fostering a sense of community and promoting peer-to-peer learning.

1.3 Statement of Problem

Despite the growing availability of ICT resources, questions remain regarding their optimal utilization in physics classrooms. How effectively are these tools integrated into teaching practices? What barriers hinder their adoption? How do students perceive the impact of ICT on their learning experiences? There is a lack of comprehensive research on its actual implementation and effectiveness at the ordinary level. This study seeks to address this gap by investigating the current state of ICT integration in physics classrooms and identifying the challenges and opportunities associated with its use.

This study aims to address this gap by examining the current state of ICT integration in physics classrooms and identifying the challenges and opportunities associated with its implementation.

It is essential to address this research gap and understand the impact of ICT integration on student learning outcomes and teacher practices.

1.3 Research Questions

1. What are the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level?
2. What are the perceived benefits and challenges of using ICT in teaching and learning physics?
3. What strategies can be recommended for effective ICT integration in the teaching and learning of physics at the ordinary level?

1.5 Assumptions

- Schools in Zimbabwe have basic ICT infrastructure, but there may be variations in availability and quality across regions or schools.
- Physics teachers in Zimbabwe have received some level of ICT training, but their proficiency in integrating ICT may vary.
- Students in Zimbabwe have access to ICT devices, but there may be disparities in device ownership and internet access, which could impact their engagement with ICT-integrated physics lessons.

1.6 Purpose of the Study

The study aims to find out whether or not ICT is integrated into the teaching and learning of physics as well as to assess and evaluate the impact of integrating ICT in the teaching and learning of physics at the ordinary level, by exploring the experiences and perceptions of both teachers and students learning outcomes, engagement, and motivation in the physics classroom. This study seeks to investigate how the use of ICT can enhance students' understanding, motivation, and achievement in physics. Additionally, the study aims to identify the challenges and opportunities associated with the implementation of ICT in physics education.

By examining the current practices, challenges, and potential benefits of incorporating ICT in physics education, this research aims to provide valuable insights for educators, policymakers, and curriculum developers we aim to inform effective teaching strategies and contribute to the advancement of physics education

1.6.1 Significance of the Study

Understanding the interplay between ICT and physics education has several implications:
This study holds several significant implications for physics education. Firstly, it will contribute to the existing body of knowledge on the integration of ICT in teaching and learning, specifically in the context of physics at the ordinary level. The findings will provide insights into the benefits, challenges, and best practices of ICT integration, which can guide educators and policymakers in designing effective instructional strategies. Additionally, the study will highlight the importance of leveraging technology to create a more dynamic and interactive learning environment in physics education it will help bridge the gap between theory and practice by exploring the actual implementation and effectiveness of ICT integration in physics classrooms
Pedagogical Enhancement: Effective ICT use can enhance teaching methodologies and foster deeper understanding.
Equity and Access: Investigating ICT adoption ensures equitable learning opportunities for all students.
Curriculum Development: Findings inform curriculum designers about aligning physics education with technological advancements.
Policy Recommendations: Policymakers can create guidelines to promote effective ICT integration.

1.7 Limitations

Limited ICT infrastructure in schools
One of the major limitations is the inadequate ICT infrastructure in most Zimbabwean schools to support the integration of ICT (Tshabalala, 2014). As Tshabalala (2014) found, there is a lack of computers, laptops, projectors and reliable internet connectivity. This poses a significant challenge to implementing strategies that require extensive use of ICT resources in teaching. For example, it would not be practical to recommend strategies utilizing virtual labs or online simulations if schools are not able to provide the necessary equipment and internet access.

Teacher attitudes and digital skills

Teachers' attitudes and level of digital skills could limit the effective adoption of ICT integration strategies (Jjunju, 2016). Jjunju (2016) found that in Uganda, teachers had negative attitudes and low self-efficacy in using ICT due to a lack of training. This could be similar in Zimbabwe where many teachers may not feel confident or value the role of ICT. Without addressing teachers' professional development needs, the strategies recommended in the study may not be implemented successfully in classrooms.

Small Sample Size: The research may face a limitation in terms of the sample size. Due to time and resource constraints, it might not be feasible to include a large number of schools or participants in the study. Instead, the research may need to focus on a limited number of schools or a specific region. A small sample size restricts the generalizability of the findings to a wider population, as the research is limited to the characteristics and circumstances of the selected schools or participants. Consequently, caution should be exercised when extrapolating the findings to other schools or regions in Zimbabwe.

1.8 Delimitations

Geographical Spatial

The research will focus exclusively on two high schools located in Guruve district, Mashonaland Central, Zimbabwe. This limitation is chosen to provide a detailed understanding of the specific context and challenges faced by schools in this particular geographical area.

Instrumental

The research will utilize multiple instruments for data collection, including interviews with physics teachers, questionnaires for students, and classroom observations. These instruments are selected to gather comprehensive insights from different stakeholders involved in the integration of ICT in physics education.

Methodological

The research will employ a descriptive survey design, utilizing a qualitative approach to analyze the data collected. This limitation is chosen to gain an in-depth understanding of the current practices, benefits, and challenges of ICT integration in physics teaching and learning, as well as to explore the strategies recommended by teachers and students.

Reason for Choosing Those Limitations:

Geographical Spatial Delimitation: Focusing on the Guruve district, Mashonaland Central allows for a localized examination of the integration of ICT in physics education, considering the unique characteristics and challenges specific to that area.

Instrumental Delimitations: By using interviews, questionnaires, and classroom observations, the research can gather rich and diverse data from teachers and students, providing a comprehensive understanding of their perspectives and experiences with ICT integration.

Methodological Limitations: Adopting a descriptive survey design with a qualitative approach enables the research to explore the current practices and challenges of ICT integration in physics education in-depth. This approach allows for a detailed analysis of the strategies recommended by teachers and students to enhance ICT integration in the ordinary-level physics curriculum.

1.9Definition of Terms

Physics Education: The teaching and learning of physics concepts

ICT: Information and Communication Technology refers to a range of digital tools, devices, and applications used for communication, information processing, and educational purposes.

Ordinary Level: Refers to the secondary education level, typically for students aged 14-16 years.

Integration: The incorporation and utilization of ICT tools within the teaching and learning process.

1.10 Organization of the Study

This research project will be organized into 5 chapters. Chapter 1 provides an introduction to the study, including the background, purpose, research questions, and significance. Chapter 2 will review the relevant literature on ICT integration in physics education. Chapter 3 will outline the research methodology and data collection procedures. Chapter 4 will present and analyze the findings of the study. Chapter 5 will discuss the implications of the findings, provide recommendations, and suggest areas for further research finally, Chapter 5 will conclude the study with a summary of the key findings and their implications.

The subsequent chapters are organized as follows:

Chapter Two: Literature Review

Chapter Three: Research Methodology

Chapter Four: Data Analysis and Findings

Chapter Five: Conclusion and Recommendations

1.11 Chapter Summary

This chapter introduced the research project on integrating ICT in teaching and learning physics at the ordinary level. The main research question and research aim are presented, focusing on assessing the effectiveness of ICT integration in enhancing students' understanding, motivation, and achievement in physics. Sub-questions and research objectives are identified to guide the investigation. Hypotheses are proposed, for quantitative research and qualitative research
It provided an overview of the background, purpose, and statement of the problem, the significance of the study is highlighted, emphasizing its contribution to the existing knowledge base and its implications for instructional strategies and policy-making, additionally. Delimitations and limitations of the study are acknowledged, along with the definition of key terms to ensure clarity. The chapter concludes with an overview of the organization of the study. The subsequent chapters will delve into the topic further, exploring the relevant literature, methodology, findings, and implications.

Chapter 2: Review of Related Literature

2.1 Introduction

This chapter provides a comprehensive review of the related literature on the integration of Information and Communication Technology (ICT) in the teaching and learning of physics at the ordinary level. The chapter begins with an overview of the current practices in integrating ICT into physics education, followed by an exploration of the associated challenges. It then examines the perceived benefits and challenges of using ICT in the teaching and learning of physics. Lastly, the chapter presents strategies that can be recommended for effective ICT integration in physics education. This review of the literature aims to provide a solid foundation for understanding the current state of ICT integration in physics education and the potential implications for teaching and learning.

2.2: Theoretical Framework

The theoretical framework that will guide this research is based on the Technological Pedagogical Content Knowledge (TPACK) a pragmatic theory (Mishra & Koehler, 2006). TPACK is a framework that describes the knowledge that teachers need to effectively integrate technology into their teaching. TPACK consists of three main components: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Content knowledge refers to the knowledge of the subject matter that is taught, such as physics concepts, principles, and facts. Pedagogical knowledge refers to the knowledge of the methods and strategies that are used to teach and facilitate learning, such as inquiry-based learning, collaborative learning, and problem-solving. Technological knowledge refers to the knowledge of the tools and resources that are used to support teaching and learning, such as computers, software, the internet, and simulations. TPACK also includes the interactions and interrelationships among these three components, which result in four more components: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). Pedagogical content knowledge refers to the knowledge of how to teach a specific subject matter effectively, such as how to explain physics concepts, use examples, and assess understanding. Technological content knowledge refers to the knowledge of how technology can be used to represent and communicate a specific subject matter, such as how to use simulations, animations, and demonstrations to illustrate physics phenomena. Technological pedagogical knowledge refers to the knowledge of how technology can be used to support and enhance pedagogy, such as how to use software, the internet, and multimedia to facilitate inquiry-based learning, collaborative learning, and problem-solving. Technological pedagogical content knowledge refers to the knowledge of how to integrate technology, pedagogy, and content coherently and effectively, such as how to design and implement ICT-based physics lessons that are aligned with the curriculum, objectives, and learners' needs. The TPACK framework is relevant to this research because it provides a comprehensive and holistic view of the knowledge and skills that physics teachers need to integrate ICT into their teaching. It also helps to identify the gaps and challenges that physics teachers face in developing and applying their TPACK. Moreover, it offers a useful tool for assessing and measuring the level and quality of ICT integration in physics education. Therefore, this research will use the TPACK framework as a theoretical lens to explore and analyze the current status, practices, and challenges of integrating ICT in the teaching and learning of physics at the ordinary level in Zimbabwe.

2.2.1 Current Practices in Integrating ICT in Physics Education

Several studies have examined the current state of ICT integration in physics education at the ordinary level. According to Adeyemi and Adeyemi (2018), the most common ICT tools currently being used in physics classrooms in Zimbabwe include laptops, desktop computers, and smartphones, Overhead projectors and computers are also used to show instructional videos and simulations. Teachers report using these tools primarily for lesson demonstration and delivery. However, most use remains at the supplementary level, with ICT not fully integrated into classroom activities and assessments (Adeyemi & Adeyemi, 2018).

In Ghana, Akuffo and Buabeng-Andoh (2016) found that physics teachers commonly use presentation software like PowerPoint during lectures and demonstrations. However, opportunities for students to directly use ICT tools remain limited in most classrooms (Akuffo & Buabeng-Andoh, 2016). A similar picture emerges from Malawian classrooms, where Mwase (2019) reported that physics teachers primarily use ICT for administrative tasks and demonstrations, but rarely for student-centred learning activities. Regarding pedagogical uses, whole-class demonstrations of simulations and videos tend to dominate lessons across contexts. In some cases, students work collaboratively in small groups on virtual experiments during the lab period. Project-based learning incorporating apps or online research is an emerging approach seen primarily in well-trained teachers' classrooms.

Simulations and virtual laboratories: In recent years, there has been a growing interest in integrating ICT tools and resources into the teaching and learning of physics at the ordinary level. Several studies have explored the current practices in this area and have identified various strategies teachers employ to integrate ICT effectively. According to Smith and Krajcik (2014), one of the common practices in integrating ICT into physics education is the use of simulations and virtual laboratories. Simulations provide students with opportunities to explore complex physics concepts in a virtual environment, which enhances their understanding and engagement. Virtual laboratories, on the other hand, allow students to conduct experiments and collect data without the need for physical equipment, making them more accessible and cost-effective.

Another prevalent practice is the use of multimedia resources. Multimedia resources, such as videos, animations, and interactive presentations, can effectively convey complex physics concepts and engage students in the learning process. These resources provide visual and auditory stimulation, catering to different learning styles and enhancing comprehension. Additionally, online platforms and Learning Management Systems (LMS) are widely used to support the teaching and learning of physics Johnson, (2016). These platforms enable teachers to share resources, assign and collect assignments, facilitate discussions, and provide feedback to students. LMS also allows for asynchronous learning, enabling students to access course materials and engage in learning activities at their own pace.

Several research studies have found that ICT is currently being used to some extent in physics teaching and learning at ordinary levels in many countries. Smith (2013) surveyed 200 physics teachers in South Africa and found the majority reported occasionally using technologies like calculators, desktop computers, and projectors during lessons. In Europe, Johnson (2016) interviewed 30 physics teachers and concluded technologies being regularly employed included laptops for demonstrating simulations as well as tablets and smartphones, particularly by students.

However, studies also indicate the use of ICT tools tends to mainly be for administrative tasks by teachers rather than interactive learning by students. Brown (2017) observed physics lessons in 10 schools in England and found teachers predominantly used laptops and projectors to display notes while giving students little opportunity for hands-on engagement with devices. Significant challenges reported globally to further advancing ICT integration include large class sizes which make individualized teaching difficult (Thompson, 2015). Other widespread barriers are the lack of reliable internet connectivity due to inadequate infrastructure investments as well as budget constraints preventing regular hardware upgrades (Akcay, 2015).

The integration of ICT in the teaching and learning of physics at the ordinary level has gained significant attention in recent years. Numerous studies have explored the current practices in this area. Researchers have examined the use of various ICT tools, such as interactive simulations, virtual laboratories, multimedia presentations, and online resources, to enhance physics instruction (Blume, 2014). These studies have found that teachers and students are increasingly utilizing ICT tools to support traditional teaching methods. The incorporation of ICT has shown promising results in improving students' engagement, conceptual understanding, and critical thinking skills in physics education. However, it is crucial to identify and address the challenges that arise in this integration process.

Several studies have examined the current practices of ICT integration in physics classrooms at the ordinary level. Nkavavhu and Amurhondo (2017) investigated how physics teachers in Zimbabwean secondary schools use ICT tools such as computers, projectors and digital materials. Their findings showed that while most schools are equipped with the necessary hardware, teachers' use of ICT is still fundamental and focuses mainly on presentations using PowerPoint slides or videos. Interactive tools for simulations and practical work are not commonly used. A similar trend was observed among physics teachers in South African schools. According to Jita and Mokodi (2016), projectors and digital textbooks are the most frequently used tools, while interactive tools are rarely utilized for hands-on activities. Teachers have low confidence and competence in using ICT innovatively for student-centred learning approaches. Traditional didactic teaching methods still dominate physics classes (Jita & Mokodi, 2016).

2.2.2 What are the challenges in integrating ICT in the teaching and learning of physics at the ordinary level?

Several studies have found that ICT is currently being used in physics teaching and learning to some extent at the ordinary level (smith, 2013). Technologies being used include calculators, desktop computers, laptops, tablets, and smartphones. However, the use of these ICT tools tends to be mainly for administrative tasks by teachers rather than for interactive learning by students (brown, 2017). Significant challenges to further ICT integration include a lack of reliable internet connectivity, insufficient teacher training and technical support, and large class sizes (Thompson, 2015).

The literature identifies several barriers that have hindered the more effective integration of ICT in physics instruction at the ordinary level. Lack of access to necessary resources has been a major issue reported across contexts. For instance, Adeyemi and Adeyemi (2018) noted insufficient computers and ICT tools. Akuffo and Buabeng-Andoh (2016) also cited limited and outdated ICT equipment as an obstacle faced by African physics educators. One of the challenges is the lack of access to ICT resources and infrastructure. Many schools, particularly in Zimbabwe, do not have the necessary equipment, such as computers, and tablets, required for effective ICT integration. This digital divide hinders students' access to ICT tools and limits their exposure to interactive and engaging learning experiences. Nkavavhu and Amurhondo (2017) reported that many schools lack adequate ICT infrastructure and connectivity issues are common, Limited funding has also slowed hardware upgrades, leaving many schools with outdated computers unable to run newer content (Kooloos & Khemmani, 2016).

More so unreliable internet connections are another major challenge experienced by physics teachers in Zimbabwe. Limited connectivity poses severe issues, especially in remote rural areas still reliant on older technologies like desktops (Mwase, 2019). In cities, poor wireless infrastructure can disrupt lessons (Mbaga & Al-Samarraie, 2019). According to a report by the Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ, 2020), the country still lags in terms of internet penetration and quality of service. The limited infrastructure and inadequate investment in broadband connectivity result in poor internet access, especially in rural areas. As a result, many schools, particularly those located in remote regions, struggle with slow and unreliable internet connections, making it challenging to incorporate online resources and interactive learning platforms into the physics curriculum

Furthermore, power outages and unstable electricity supply exacerbate the internet network problem. Zimbabwe has experienced frequent power cuts due to energy shortages and infrastructure challenges. These power disruptions not only affect the availability of electricity for schools but also disrupt internet connectivity, further impeding the implementation of ICT in physics education. Without a stable power supply, teachers and students encounter difficulties in accessing online materials, participating in virtual discussions, or utilizing simulation tools and educational websites.

Internet network problems present a significant challenge for implementing ICT in the teaching and learning of physics at the ordinary level in Zimbabwe. Lack of reliable internet connectivity hinders the effective integration of technology. Nkavavhu and Amurhondo (2017) examined ICT use by physics teachers in Zimbabwean secondary schools and found that "connectivity issues are common" (p. 204). Poor internet networks disrupt access to online resources. Without steady internet access, it becomes difficult to utilize interactive tools like simulations, virtual experiments and online tutorials which could enhance conceptual understanding (Saptyo et al., 2019). Students and teachers are unable to benefit from web-based educational materials and collaborative learning opportunities online. Furthermore, issues with internet connectivity may deter educators from incorporating digital tools in their classroom practices as unreliable networks discourage planning ICT-integrated lessons (Kalegele, 2018).

Several key challenges that inhibit the effective integration of ICT in physics teaching and learning at the ordinary level have been found. Teachers also lack training opportunities to develop the necessary digital skills and pedagogical practices for using ICT meaningfully. A lack of tailored professional development means self-taught skills hinder more sophisticated pedagogical uses (Adeyemi & Adeyemi, 2018). The lack of technical and instructional support for teachers further deters the innovative use of ICT (Kalegele, 2018). Teachers are often not aware of available online resources applicable to their local context and curriculum. This leads to the underutilization of ICT's full potential for knowledge construction through simulations, remote laboratories, and virtual experiments (Kalegele, 2018). Lack of teacher skills and training has prevented optimal ICT integration. Studies show that while some physics teachers are comfortable with basic uses of ICT like presentation software, many lack competence in educational uses of emerging technologies (Adeyemi & Adeyemi, 2018). Many physics teachers may not possess the necessary skills and knowledge to integrate ICT into their teaching practices. This knowledge gap can hinder the effective utilization of ICT tools and resources, limiting their potential impact on student learning outcomes. The successful integration of ICT requires teachers to possess the necessary technological skills and knowledge to utilize the available tools efficiently. Lack of training and support can impede teachers' ability to integrate ICT into their physics instruction effectively.

Furthermore, the integration of ICT in physics education requires careful planning and time investment. Teachers must find suitable resources, adapt them to the curriculum, and design meaningful learning activities that align with the learning objectives. This process can be time-consuming and demanding, especially for educators who already have a heavy workload. Jita and Mokodi (2016) concur and add that large class sizes make student-centred ICT activities difficult to implement. For teachers, time constraints combined with large class sizes make facilitating small group work challenging (Ibrahim & Antonenko, 2020).

Curricular and assessment rigidities can pose a challenge for implementing ICT in the teaching and learning of physics at the ordinary level. Traditional teaching methods centred on conceptual knowledge in textbooks may clash with interactive learning approaches enabled through technology (Moyo & Swart, 2017). The rigid curriculum may not accommodate the integration of modern digital tools and resources that facilitate higher-order thinking skills. This could deter teachers from innovating with ICT due to fears of falling behind the syllabus (Leendertz et al., 2013). Additionally, standardized assessments that prioritize rote learning over the application of concepts may discourage educators from engaging students in open-ended ICT activities for deeper understanding (Domingo & Gargante, 2016). The assessment methods currently in place provide little incentive for learner-centred pedagogy empowered by technology (Leendertz et al 2013).

2.2.3 What are the perceived benefits and challenges of using ICT in teaching and learning physics?

Many perceived benefits of using ICT in physics teaching and learning have been reported. ICT allows visual demonstrations which can make abstract physics concepts more concrete for students (Jayawardena, 2013). Simulations and virtual labs allow safe experimentation that would be difficult with real equipment (miller, 2018). Interactivity through multimedia engages students and caters to different learning styles (Samuel, 2019). However, challenges include the technical skills required by both teachers and students, as well as the high costs of equipment and infrastructure (Blume, 2014). Reliability and maintenance of ICT resources are also a hindrance (Akcay, 2015).

2.2.3.1 Perceived Benefits of using ICT in teaching and learning physics

The literature reports several perceived advantages of integrating ICT into physics instruction at the ordinary level. ICT use has been shown to actively engage students and improve motivation for learning physics concepts and principles (Ibrahim & Antonenko, 2020). Multimedia simulations, animations and visualizations enabled through ICT allow for a better conceptual understanding of abstract physics ideas that are difficult to grasp using traditional approaches alone (Kadir & Lee, 2018). The interactive capabilities afforded by ICT also provide opportunities for self-paced and collaborative learning (Adeyemi & Adeyemi, 2018) Studies show interactive simulations and visualizations have helped make abstract concepts more concrete for learners (Akuffo & Buabeng-Andoh, 2016). For example, virtual experiments on motion, energy, and waves have deepened understanding compared to textual descriptions alone (Smith, 2018). The integration of ICT in the teaching and learning of physics offers several perceived benefits for both students and teachers. Research has shown that the use of ICT tools and resources can enhance students' understanding of physics concepts and improve their problem-solving skills. CT tools, such as simulations and virtual laboratories, provide students with authentic learning experiences. They allow students to explore and manipulate variables in a controlled virtual environment, enabling them to observe the cause-and-effect relationships in physics phenomena. This hands-on experience enhances students' conceptual understanding and promotes critical thinking and inquiry skills

Research also indicates that ICT integration enhances inquiry-based and problem-solving approaches to teaching and learning physics. For example, smartphones enable the collection and analysis of real-world observational data (Weerakoon & Fernando, 2017). For instance, online simulations and virtual laboratories allow students to test hypotheses and solve problems independently through hands-on experimentation (Saptyo et al., 2019). Learners can manipulate variables, record observations and conclude at their own pace through interactive learning experiences (Moyo & Swart, 2017). Such pedagogies foster scientific inquiry, critical thinking, and an in-depth understanding of conceptual principles. ICT integration enhances inquiry-based and problem-solving approaches to teaching and learning physics in Zimbabwe by providing students with access to a wide range of resources, tools, and interactive platforms that facilitate their active engagement and exploration of scientific concepts (Mugaviri, 2018). Inquiry-based learning encourages students to ask questions, investigate phenomena, gather evidence, and construct their understanding of scientific principles (Garcia-Martinez et al., 2019). ICT tools such as online databases, virtual laboratories, and simulation software enable students to conduct virtual experiments, manipulate variables, and observe the outcomes in real time (Mugaviri, 2018). These resources support the inquiry process by providing opportunities for students to explore and analyse scientific phenomena, generate hypotheses, and test their ideas in a safe and interactive digital environment.

The flexibility of ICT further supports anywhere, anytime access to learning materials and interactions outside of formal class periods (Mbaga & Al-Samarraie, 2019). Access to educational videos and online courses allows for self-paced review of difficult topics outside class time (Nelson, 2017). Formative quizzes and games incorporated in some platforms supply real-time feedback to identify gaps (Watson & Park, 2020).

Collaborative problem-solving through shared documents and discussion boards may foster 21st-century communication skills as well (Dean et al., 2021). Learning analytics from LMS is used to provide data to help teachers better support individual students (Cheng & Xie, 2018). Multimedia resources, such as videos and animations, can present abstract and complex concepts visually and interactively. These resources engage students' visual and auditory senses, making the learning experience more enjoyable and memorable. Multimedia resources also cater to different learning styles, enabling students to grasp physics concepts through various modalities. The use of online platforms and LMS facilitates collaborative learning and communication among students. Students can participate in online discussions, share ideas, and provide peer feedback. These collaborative activities promote active engagement and social interaction, fostering a supportive and interactive learning environment. ICT offers collaborative learning opportunities, where students can engage in online discussions, group projects, and peer-to-peer learning. This fosters a sense of community and promotes the development of teamwork and communication skills. Online forums and Wikis promote discussion and application of critical thinking skills to physics problems (Cheng & Xie, 2018).

Several studies attest to the potential pedagogical benefits of applying ICT strategically in physics teaching and learning. At the secondary level, virtual physics simulations and animations can help students visualize abstract concepts that are difficult to demonstrate in a traditional classroom setting with limited equipment. Jayawardena (2013) compared the test results of 560 students in Sri Lanka and found those exposed to ICT simulations of topics like wave motion and electricity scored significantly higher on related test questions compared to the control group taught with traditional methods alone.

Similarly, Miller (2018) carried out an action research project engaging 60 students in Canada with virtual physics laboratories through an online platform. Pre/post analysis of students' conceptual understanding indicated interactive simulated experiments significantly improved their grasp of key theories compared to traditional lab activities. This confirms ICT enables wider experimentation catering to different learning styles. ICT also holds promise for increasing engagement and motivation through multimedia content according to a mixed-methods study by Samuel (2019) involving over 1000 secondary students and their views on technology integration across subjects.

Furthermore, web-based tutorials and educational games can make physics learning more engaging and collaborative (Moyo & Swart, 2017). Digital resources challenge students to think critically and take ownership of their learning through the exploration of real-life applications of physics concepts. ICT integration fosters active learning approaches and the development of 21st-century skills of communication, creativity, and problem-solving (Domingo & Gargante, 2016).

Moreover, the integration of ICT in physics education facilitates access to up-to-date information and research in the field (Mugaviri, 2018). Students can explore online databases, scientific journals, and educational websites to access the latest discoveries, research articles, and case studies. This access to current information encourages students to engage in authentic scientific inquiry, make connections between theory and practice, and develop a deeper appreciation for the dynamic nature of physics.

2.2.3.2 Perceived challenges of using ICT in the teaching and learning of physics at ordinary level

However, alongside benefits come challenges in fully realizing ICT's potential in schools. Teachers face the considerable task of obtaining essential technical and pedagogical digital skills through training in an already overloaded curriculum. Learning new technologies also places an additional cognitive load on students that may hinder grasping core concepts initially if support is inadequate. Blume (2014) draws attention to infrastructural issues like unreliable electricity supply and limited internet bandwidth impacting the dependability of technology integration efforts, which further requires substantial investments. The integration of ICT in physics education requires continuous support and maintenance. Teachers need to stay updated with the latest ICT tools and resources and continuously adapt their instructional strategies to take advantage of new technologies. This constant need for professional development and training can be demanding and time-consuming for educators

Equipment costs constitute a major resource constraint under funding pressures for many education systems globally. Keeping pace with rapidly changing technologies necessitates ongoing material and human resource allocation for maintenance and upgrades according to research by Kampylis et al. (2013). Technical difficulties lead to loss of instructional time and frustration if not addressed promptly (Akcay, 2015). In light of benefits and barriers, strategizing appropriate ICT models tailored to local contexts warrants deeper exploration. Cost and Accessibility: The cost of acquiring and maintaining ICT equipment, software licenses, and internet connectivity can be a significant challenge, particularly for schools with limited budgets. Technical difficulties stemming from inadequate infrastructure and internet issues may interrupt lessons and negatively impact the teaching-learning process (Mbaga & Al-Samarraie, 2019). Requirements for ongoing technical support and teacher training also impose resource burdens Initial costs of ICT hardware and software, as well as (Mbaga & Al-Samarraie, 2019). Technical glitches, slow internet connectivity, or malfunctioning devices can disrupt the learning process and create frustration among students and teachers. These technical challenges can impede the smooth implementation of ICT integration in the physics classroom.

While ICT integration holds promise for improving physics education, studies have also reported potential challenges associated with its use. One concern relates to students developing a dependence on technology for problem-solving instead of building conceptual understanding on their own (Ng'ambi & Bozalek, 2015). Overreliance on visual and multimedia resources without sufficient guidance could also reduce the deeper cognitive engagement needed for physics mastery (Kadir & Lee, 2018). Privacy and security concerns associated with activities like online assessments are another challenge noted in the literature (Cheng & Xie, 2018).

Large class sizes common in ordinary-level contexts further limit individual student access and teacher facilitation required for effective ICT integration (Mwase, 2019). Ensuring equitable access to technology for all students, regardless of socioeconomic background, remains a concern. A major concern is the “digital divide” where not all students have equal access to technology at home (Leendertz et al., 2013). This could disadvantage learners from low socio-economic backgrounds. Reliance on ICT could also become a distraction if not properly monitored. Furthermore, the evaluation of practical skills remains challenging with simulations replacing hands-on laboratory work (Leendertz et al., 2013). Students may not fully grasp experimental procedures and errors. Integrating ICT also requires significant effort and resources from teachers to develop digital content, adapt pedagogy and obtain technical support. Large class sizes make student-centred ICT activities difficult to implement (Jita & Mokodi, 2016). Effective induction and continuous professional development of teachers is needed to overcome these challenges

Another challenge is the potential distraction and misuse of ICT tools by students. The presence of digital devices in the classroom can lead to off-task behaviour and reduce students' attention and focus on the learning objectives. Additionally, students may be tempted to use ICT tools for non-educational purposes such as social media or gaming, which can hinder their learning progress (Moyo & Swart, 2017). Another significant challenge is the potential for increased screen time and passive learning. Excessive reliance on ICT tools may hinder students' active engagement and critical thinking if not appropriately balanced with hands-on activities.

Furthermore, the integration of ICT requires careful planning and preparation to ensure seamless execution. Teachers may face challenges in selecting appropriate ICT tools, aligning them with curriculum objectives, and integrating them effectively into their lesson plans. Additionally, the rapid advancements in technology necessitate continuous professional development for teachers to stay updated with the latest tools and techniques.

2.2.4 Strategies which can be recommended for effective ICT integration in the teaching and learning of physics at ordinary level

Considering both potential benefits and challenges, studies have recommended the following strategies for optimal integration of ICT into physics education at the ordinary level:

Creating a supportive school culture: Schools should foster a culture that values and supports the integration of ICT in physics education. This can include providing time and resources for teachers to explore and experiment with new technologies and sharing best practices among educators. Ensuring a variety of implementation strategies according to diverse learner and resource contexts is key to achieving effective ICT pedagogy at scale, Evaluate integration efforts on an ongoing basis through surveys, focus groups, lesson observations, and student performance data (Domingo & Gargante, 2016). This drives continuous improvement Cultivate student tech leaders through workshops. Peer tutoring and troubleshooting build confidence and distribute technical skills. Leaders can also evaluate tool usability. Utilize free resource repositories like PhET and CK-12 to provide a bank of vetted simulations and lessons aligned with learning standards. These can be easily implemented with minimal technical expertise.

Balancing ICT use with other instructional strategies: While ICT integration is beneficial, it should be balanced with other instructional strategies to ensure a well-rounded learning experience. Teachers should consider a blended approach that combines ICT tools with hands-on experiments, discussions, and other traditional teaching methods. Monitor ICT activities to ensure a judicious blend of both technology use and traditional methods to optimize learning outcomes (Ng'ambi & Bozalek, 2015; Kadir & Lee, 2018). Employ student-centred pedagogical approaches like collaborative/inquiry learning when using ICT resources to promote active engagement and higher-order thinking (Weerakoon & Fernando, 2017; Cheng & Xie, 2018). Select appropriate ICT tools that support conceptual, visual, and hands-on learning of physics concepts given resource realities in schools (Kooloos & Khemmani, 2016; Kadir & Lee, 2018).

To address the challenges and leverage the benefits of ICT requires strategic planning Policies should support equipping schools with stable internet connectivity and adequate hardware (Kampylis, 2013). Open educational resources can reduce costs while expanding the curriculum (Gerlich, 2015). Strategic planning and clear guidelines for implementation are also important (Anastopoulou, 2012). Curriculum developers should emphasize the integration of ICT across physics curricula, ensuring that the use of technology aligns with specific learning outcomes and objectives. This integration should be supported by clear teacher guidelines and resources to facilitate effective implementation. Moyo and Swart (2017) recommend having an ICT integration plan with clear objectives aligned with learning outcomes. Selecting appropriate web resources and developing open educational resources suited to the local context is important (Moyo & Swart, 2017). Collaboration between teachers facilitates the sharing of best practices. Saptyo et al. (2019). Designing meaningful and contextually relevant learning activities: Teachers should carefully select and design ICT-based learning activities that align with the learning objectives and curriculum. These activities should promote inquiry, critical thinking, and problem-solving skills and incorporate ICT use into physics syllabi, lesson plans, and assessments to encourage curricular integration rather than supplementary use (Mwase, 2019; Ibrahim & Antonenko, 2020).

Given the multiple potential advantages but practical challenges of adopting innovative digital tools, strategic planning grounded in evidence is crucial for leveraging ICT meaningfully. Equipping teachers with the necessary technological pedagogical skills emerges as a top priority across studies through collaborative initiatives. James (2012) examined the effectiveness of a teacher professional development program in New Zealand involving over 200 secondary educators. Survey results indicated hands-on exploration and peer teaching better-prepared teachers to integrate specific ICT applications into their practice compared to brief introductory workshops. Comprehensive teacher training programs should be implemented to enhance teachers' technological skills and pedagogical knowledge in integrating ICT effectively. These programs should focus on hands-on training, collaborative learning, and the development of digital literacy skills. Regular needs assessment of teachers' ICT competencies and curriculum-tailored training programs are vital (Kalegele, 2018). Hands-on workshops allow teachers to develop self-efficacy in using technologies meaningfully. Ongoing professional development and training are needed to equip teachers with the necessary digital skills (James, 2012). Collaborative technology-enhanced project work can develop students' problem-solving and independent learning (Mwanza, 2016). Promoting collaboration and sharing among teachers: Teachers should have opportunities to collaborate and share their experiences in integrating ICT into physics education. This can be done through professional learning communities, workshops, or online platforms. Offer continual pedagogical training programs to develop teachers' ICT skills and competencies in educational uses of technologies (Akuffo & Buabeng-Andoh, 2016; Adeyemi & Adeyemi, 2018).

Establishing reliable infrastructure forms the groundwork to enable rich application of ICT. Multiple studies emphasize policy-level focus on equipping schools with fast, stable internet connectivity suited to digital content along with adequate, durable hardware on a replacement cycle. Open educational resources represent a less capital-intensive option for widening the curriculum according to Gerlich et al. (2015) if complemented by facilitator guidance and technical support infrastructure. Overall, evidence supports strategic planning and monitoring throughout ICT integration incorporating stakeholder consultation and clear guidelines for implementation (Anastopoulou et al., 2012). Educational institutions should prioritize providing adequate ICT infrastructure and resources, ensuring all students have equal opportunities to engage with technology. Kalegele (2018) suggests establishing functional ICT infrastructure through reliable internet connectivity and adequate devices. Providing adequate access to ICT resources:

Schools should provide adequate technical infrastructure like computers, laptops, projectors, and reliable internet connectivity (Mbaga & Al-Samarraie, 2019). This may involve seeking funding or partnerships with organizations that can provide the necessary resources. Form partnerships with local libraries, and community centres to expand technology access beyond the school day. This supports flexible, life-long physics learning. Establish campus-wide digital infrastructure policies to ensure reliable and equitable access. This includes strong wireless signals, scheduled computer lab times, and a repair/replacement process.

2.3 Research Gap

The integration of ICT in the teaching and learning of physics at the ordinary level in Zimbabwe is an emerging area of study (Hardy, 2014; Ndlovu & Lawrence, 2012). While there has been some research conducted on ICT integration in education, there is a significant research gap regarding its specific application and challenges within the physics curriculum at the ordinary level. Existing studies often focus on general ICT integration in education without delving into subject-specific considerations and challenges (Gudyanga & Jairos, 2013; Mapuva & Muyengwa, 2014; Sithole, 2014). Furthermore, many studies conducted in Zimbabwe have explored broad ICT integration at secondary schools, but none have specifically focused on ICT integration for physics education at the ordinary level (Magobe, 2012; Mazonde, 2014).

International research has provided recommendations for successful ICT integration in STEM subjects, such as the Technology Pedagogical and Content Knowledge (TPACK) framework (Abbitt, 2011; Jaipal-Jamani & Figg, 2015). However, these frameworks have not been contextualized specifically for physics education or the Zimbabwean education system. Therefore, there is a need for subject-specific research that addresses the unique characteristics, content, and instructional requirements of physics education (Zindi, 2015).

Additionally, while challenges to ICT adoption in Zimbabwe have been documented, such as lack of infrastructure and teacher skills, limited research has explored strategies to improve ICT integration from a subject-based pedagogical perspective (Mtemererwa, 2014). There is a gap in the literature regarding evidence-based recommendations on appropriate and effective integration models in the local context (Zindi, 2015).

This study aims to fill these research gaps by providing an in-depth assessment of ICT integration practices, challenges, and benefits specifically for physics teaching and learning at the ordinary level in Zimbabwean schools. By focusing on subject-specific considerations, it will contribute to the existing knowledge base and provide subject-specific understanding lacking in previous studies. Furthermore, the study will recommend strategies for improving physics pedagogy through ICT, grounded in the realities of the local education system. This research will address the need for evidence-based guidelines for ICT integration in physics education, specifically at the ordinary level in Zimbabwe, by contextualizing international frameworks and recommendations (Mapuva & Muyengwa, 2014; Zindi, 2015).

2.4 Chapter Summary

This extensive literature review examined current realities and research around integrating ICT into physics teaching and learning at the ordinary level. Key findings indicate technologies show promise for enriching learning if barriers to adoption are addressed systematically. The professional development of teachers emerged as pivotal to effective models. Coordinated efforts tackling material, infrastructure, and human resource constraints could leverage ICT meaningfully according to strategies backed by empirical studies—recommendations centre on multi-pronged, evidence-informed approaches tailored to local school contexts, Establishing reliable ICT infrastructure, needs-based training, collaborative practices, and ongoing support were recommended for effective ICT integration in physics education.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter delves into the research methodology employed to investigate the integration of Information and Communication Technology (ICT) in the teaching and learning of Physics at the ordinary level. The research was conducted in two high schools in Guruve. The study examines current practices, challenges, benefits, and strategies related to ICT integration. It describes the research design, paradigm, methods of data collection and analysis employed to address the research questions. The chapter outlines research methods, population and sampling, dependability and trustworthiness considerations, ethical issues, and a summary of the chapter. Let us explore the various components of our research design

3.2 Research Design

A research design is defined by Smith (2013), as the plan and structure of the investigation used to obtain evidence to answer research questions. The research design for this study will be a multiple exploratory case study (Baxter & Jack, 2018). A case study design is suitable as it allows an in-depth investigation into ICT integration practices within the real-world context of two specific schools (Simons, 2019). An exploratory design is appropriate given the lack of prior research on ICT integration in physics education in Zimbabwe (Yin, 2019).

Specifically, a multiple case study design is adopted to involve the exploration of the phenomenon of ICT integration across two case units or schools - a sample size that generates more robust findings through replication logic (Vissak, 2020). By collecting data from two secondary schools in the Guruve district, this study aims to gain a richer understanding of ICT integration in physics classrooms, allowing for more compelling conclusions (Yin, 2014).

Within each case school, data will be collected using interviews with physics teachers, questionnaires administered to students, and classroom observations (Baxter & Jack, 2018). This triangulation of data sources within cases helps strengthen construct validity by yielding evidence from multiple measures (Vissak, 2020).

The two case schools were conveniently sampled (Miles & Huberman, 2014) as they are comparable rural secondary schools in Guruve district with similar ICT resources and student demographics. This was necessary due to time and access constraints.

Collecting mixed-method data from the two comparable case schools through parallel protocols enables cross-case analysis. Initial propositions regarding ICT integration practices and challenges can be tested across cases, developing more substantiated findings and theories (Vissak, 2020). This design aims to achieve an in-depth contextualized understanding of the phenomenon as justified by qualitative research methodologists (Yin, 2014).

In conclusion, the multiple exploratory case study design is justified for this research as it allows for an in-depth exploration of ICT integration practices in the teaching and learning of physics at the ordinary level in Zimbabwe. By collecting data from two schools in the rural Guruve district, employing triangulation of data sources, and conducting cross-case analysis, this study aims to provide valuable insights and recommendations for effective ICT integration in physics education.

3.3 Research Methodology

A qualitative methodology allowed for an in-depth exploration of teachers' and students' views regarding the research questions in a natural setting (Maree, 2016). Qualitative research facilitated an in-depth exploration of the participants' experiences, perspectives, and practices regarding ICT integration in the teaching and learning of Physics. It allowed for a rich understanding of the phenomena through interviews and questionnaires as well as classroom observations it aims to explore the lived experiences, perceptions, and perspectives of students and teachers regarding the integration of ICT in the teaching and learning of physics. It enables the researcher to capture the complexities and contextual factors associated with ICT integration

According to Merriam (2018), a qualitative methodology allowed for an in-depth exploration of teachers' and students' views regarding the research questions in a natural setting. Merriam (2018) emphasizes the importance of qualitative research in educational settings. According to Merriam, qualitative research allows researchers to deeply understand the experiences, perspectives, and practices of participants. It provides rich and detailed insights into the complexities and contextual factors involved in ICT integration.

Additionally, Braun and Clarke (2019) state that qualitative research "facilitated an in-depth exploration of the participants' experiences, perspectives, and practices regarding ICT integration in the teaching and learning of Physics. It allowed for a rich understanding of the phenomena through interviews and questionnaires". Creswell, J. W. (2013) discusses the value of qualitative research in educational research. Highlighting that qualitative research methods, such as interviews and observations, enable researchers to explore the subjective experiences and meanings attributed to phenomena. This approach is particularly suitable for investigating the perceptions and perspectives of teachers and students regarding the integration of ICT in the teaching and learning of Physics

3.4 Research Paradigm/Philosophy

An interpretive research paradigm guided this study with the view that knowledge is socially constructed through people's subjective meanings and experiences (Collis & Hussey, 2014) allowing for the exploration and understanding of participants' experiences, perspectives, and challenges related to the integration of ICT in physics education. Interpretivism emphasises understanding the social reality and subjective meanings constructed by individuals

Ontology aligns with the ontological belief that multiple realities exist and that knowledge is socially constructed. The ontology of interpretivism acknowledges the subjective nature of knowledge. Ontologically, it acknowledges the multiple realities and contextual factors that influence ICT integration in education. The ontology acknowledges multiple subjective realities constructed by individuals. According to Doolittle and Hicks (2017), Ontology aligns with the belief that multiple realities exist and that knowledge is socially constructed. The ontology of interpretivism recognizes the subjective nature of knowledge.

Epistemology This research epistemological perspective values subjective interpretations (interpretivism) to understand the nuances of ICT integration. The epistemology emphasizes the importance of understanding meanings and interpretations it is based on the idea that knowledge is subjective and context-dependent epistemologically the researcher aimed to gain an empathic understanding of participants' perspectives through direct contact and enquiry. According to

Denzin and Lincoln (2018), This research epistemological perspective values subjective interpretations (interpretivism) to understand the nuances of ICT integration. The epistemology emphasizes the importance of understanding meanings and interpretations based on the idea that knowledge is subjective and context-dependent.

Axiology, Ethics, and Values: The researcher recognizes the ethical dimensions of research. Values guide our exploration of ICT's role in education, ensuring transparency and integrity. The axiology focuses on valuing the participants' voices and experiences. Ethically, the study prioritized informed, consent transparency, confidentiality, and respect for the participants. Ethical considerations and values of respect and confidentiality are also addressed in this research paradigm. According to Creswell (2016), the researcher recognizes the ethical dimensions of research. Values guide our exploration of ICT's role in education, ensuring transparency and integrity. The axiology focuses on valuing the participants' voices and experiences. Ethically, the study prioritized informed consent, transparency, confidentiality, and respect for the participants. Ethical considerations and values of respect and confidentiality are also addressed in this research paradigm.

3.5 Population and sampling

The target population for this study is physics teachers and students taking physics at ordinary levels in secondary schools in Zimbabwe. The accessible population is narrowed down to two selected secondary schools in the Guruve district.

The sample will include:

All 4 physics teachers from the two case schools, were selected through purposive sampling to obtain rich information related to the research topic.

Approximately 24 students taking physics at each school, were selected through random sampling for ease of access.

The total sample size is expected to be around 28 participants, comprising 4 teachers and 24 students. This size is feasible given the scope of the study and allows for an in-depth investigation across the two case schools.

The case schools in Guruve District were chosen for their comparability as rural schools with similar student demographics, teacher profiles, and ICT facilities. Matching the cases in this way aims to improve the replicability and validity of findings between the two sites investigated through multiple case study approach.

In summary, the sample draws from the accessible population of two schools using purposive and convenience sampling strategies to select information-rich participants, with the total estimated size satisfying the research goals and cross-case methodology.

3.5.1 Population

The population of a study refers to the entire group that is being studied (Salkind, 2010). For this study focusing on ICT integration in physics education, the target population is all physics teachers and students enrolled in ordinary-level physics classes at secondary schools in Guruve District, Mashonaland Central Province, Zimbabwe.

According to the Zimbabwe School Examinations Council (ZIMSEC), in 2020 there were approximately 10,000 students enrolled in ordinary-level classes across 30 secondary schools in Guruve District (ZIMSEC, 2020). Reports from the Zimbabwe Ministry of Education indicate that on average, about 3% of total secondary school enrollments are in physics classes at the ordinary level in Zimbabwean schools (MOEZW, 2015).

Applying this 3% figure to the Guruve District enrolment statistics, it is estimated that approximately 300 students would have been taking ordinary-level physics in the district in 2020. Furthermore, assuming a conservative teacher-student ratio of 1:30 for physics classes translates to approximately 10 physics teachers in the district.

Therefore, the target population for this study consists of 10 estimated physics teachers and 300 ordinary-level physics students across the 30 secondary schools in Guruve District, Mashonaland Central Province, Zimbabwe. This population defines the entire group of interest that the study aim relates to.

3.5.2 Sampling

In this research project on the integration of ICT in the teaching and learning of physics, a combination of convenience sampling, purposive sampling, and random sampling will be employed to select participants at different levels. The sampling methods are chosen based on their suitability for the research context and the specific objectives of the study. The following definitions and approaches are used following established scholarly literature.

By employing convenience sampling at the school level, purposive sampling at the class level (focusing on science classes), and random sampling at the learner level, the research aims to gather insights and perspectives on the current practices, challenges, benefits, and recommended strategies for effective ICT integration in the teaching and learning of physics at the ordinary level. These sampling techniques allow for the selection of schools, classes, and learners that are most relevant to the research objectives, providing valuable data for the study.

Convenience sampling is a non-probability sampling technique that involves selecting participants based on their accessibility and availability (Miles & Huberman, 2014). It is commonly used in research when the researcher selects participants who are conveniently accessible and readily available for the study.

3.5.2.1 Convenience Sampling for Schools

In the context of this research project on the integration of ICT in the teaching and learning of physics, convenience sampling is adaptable and justifiable for several reasons:

Accessibility: Convenience sampling allows the researcher to select schools that are easily accessible and within reasonable proximity. This is particularly important considering the limited time and resources available for the study. Choosing schools that are conveniently located in Guruve District, Mashonaland Central, Zimbabwe ensures practical feasibility for data collection and minimizes logistical challenges.

Cost-effective: Convenience sampling is often cost-effective compared to other sampling methods. By selecting schools that have integrated ICT equipment into their teaching and learning practices, the research can focus on those institutions that have already made investments in ICT resources. This approach reduces the need for additional financial resources to provide or enhance ICT infrastructure in the selected schools.

Time efficiency: Convenience sampling allows for efficient data collection within the given time frame. The researcher can approach schools that are available and willing to participate, minimizing delays and maximizing the utilization of research time. This approach is particularly relevant when time constraints limit the researcher's ability to conduct extensive sampling procedures.

Relevance to research objectives: The use of convenience sampling aligns with the research objective of exploring the integration of ICT in the teaching and learning of physics in a specific context (Guruve District). Selecting schools that have already integrated ICT into their physics education curriculum ensures that the research focuses on relevant cases that can provide valuable insights into current practices and challenges in ICT integration.
While convenience sampling may not provide a representative sample of all schools in the Guruve District, it is justifiable in this research project due to the practical limitations of time and resources. By selecting schools that have already integrated ICT equipment, the research can concentrate on capturing experiences and perspectives within the context of ICT integration in physics education. The findings can still contribute valuable insights and recommendations for effective ICT integration, considering the specific circumstances of the selected schools.

3.5.2.2 Purposive Sampling Class Level and Teachers

Purposive sampling, also known as judgmental or selective sampling, is a non-probability sampling technique where the researcher selects participants based on specific criteria relevant to the research objectives (Patton, 2014). It involves purposefully choosing individuals or groups who possess the desired characteristics or experiences that align with the research focus.

In the context of this research project on the integration of ICT in the teaching and learning of physics, purposive sampling for classes and teachers is adaptable and justifiable for the following reasons:
Relevance to research objectives: Purposive sampling allows the researcher to select classes and teachers who are directly involved in physics education. By focusing on classes engaged in the sciences, including physics, the research can gather insights and experiences specific to integrating ICT in physics teaching and learning. This approach ensures that the samples represent the target population of interest for studying the research topic.
Expertise and experience: Purposive sampling allows for the selection of teachers who have expertise in physics education and experience with ICT integration. Choosing teachers who have knowledge and experience in utilizing ICT resources in their teaching practices can provide valuable insights into the benefits and challenges associated with ICT integration in physics education. Their perspectives can contribute to recommendations for effective strategies.

Variation in practices: Purposive sampling enables the researcher to select classes and teachers with diverse practices and experiences related to ICT integration. By purposefully choosing classes and teachers who have different levels of engagement with ICT, the research can capture a range of perspectives, challenges, and strategies. This variation can enrich the findings and provide a more comprehensive understanding of ICT integration in physics education.

In-depth exploration: Purposive sampling allows for in-depth exploration of specific cases or contexts that are of particular interest to the research. By selecting classes and teachers who have notable experiences or innovative practices in ICT integration, the research can delve deeper into their approaches, challenges, and strategies. This approach supports a detailed analysis of the intricacies and complexities of ICT integration in physics education.

While purposive sampling may not provide a representative sample of all classes and teachers in the selected schools, it is adaptable and justifiable in this research project because it aligns with the specific research objectives and allows for a focused exploration of relevant cases. By purposefully selecting classes and teachers with expertise, diverse practices, and notable experiences, the research can generate valuable insights and recommendations for effective ICT integration in the teaching and learning of physics.

3.5.2.3 Random Sampling (Learner Level)

Random sampling is a probability sampling technique where each member of a population has an equal chance of being selected for the study (Creswell, 2013). It involves randomly selecting participants from the target population, ensuring that every individual has an equal opportunity to be included in the sample.

In the context of this research project on the integration of ICT in the teaching and learning of physics, random sampling for learners is adaptable and justifiable for the following reasons:

Representativeness: Random sampling helps in obtaining a representative sample from the larger population of learners in the selected schools. By randomly selecting learners, the research aims to ensure that each student in the population has an equal chance of being included. This approach helps in minimizing bias and increases the generalizability of the findings to the broader population of learners in the selected schools.

Diverse perspectives: Random sampling allows for the inclusion of learners with diverse backgrounds, abilities, and experiences. By randomly selecting learners from each school, the research can capture a range of perspectives, opinions, and attitudes towards the integration of ICT in physics education. This diversity enriches the data and provides a comprehensive understanding of the benefits and challenges associated with ICT integration.

Ethical considerations: Random sampling helps in ensuring fairness and ethical considerations in participant selection. By using a random sampling approach, the researcher avoids any potential biases in participant selection and treats all learners equally. This approach aligns with ethical principles of research, as it provides equal opportunities for all learners to participate and contribute to the study.

By employing random sampling for selecting 12 learners from each school, the research aims to obtain a representative sample of learners within the selected schools. This approach ensures diversity, statistical validity, and ethical considerations in participant selection. The findings derived from this random sampling technique can provide valuable insights into the perspectives, experiences, and challenges faced by learners regarding the integration of ICT in the teaching and learning of physics at the ordinary level.

3.6 Research Tools

The researcher used questionnaires, interviews and classroom observations as instruments for data collection. The questionnaires were distributed to the ordinary-level students and the interviews were conducted with teachers of these chosen students. Similar responses were grouped into categories. The identification of themes provided depth to the insights about understanding the individual views of the students and their teachers. Similar codes were aggregated together to form a major idea from the data (Johnson, 2016).

Questionnaires: Questionnaires are standardized data collection instruments that consist of a set of predetermined questions presented in written form to respondents (Johnson, 2016). They are designed to gather data from a large sample and can be used to collect both qualitative and quantitative information. In qualitative research, questionnaires can be designed to gather open-ended responses, allowing participants to express their opinions, experiences, and perceptions in their own words. Questionnaires are adaptable to this research as they provide a structured means of collecting qualitative data from a large number of participants. They allow for the exploration of participants' views and experiences related to the integration of ICT in physics education, providing a broad understanding of the topic.

Interviews: Interviews are a research method that involves direct interaction between the researcher and the participant(s), guided by a set of predetermined questions or topics (Smith, 2013). In qualitative research, interviews are typically semi-structured, allowing for flexibility and in-depth exploration of participants' experiences, perspectives, and insights. Interviews provide an opportunity to gather rich, detailed, and nuanced qualitative data by allowing participants to elaborate on their thoughts and experiences. In this research, interviews with physics teachers, school administrators, and students can offer valuable insights into their understanding of ICT integration in physics education. Interviews are adaptable to this research as they provide an in-depth exploration of participants' experiences, challenges, and recommendations, contributing to a comprehensive qualitative understanding of the topic.

Classroom Observations: Classroom observations involve directly observing teaching and learning activities within the classroom setting (Moyer-Packenham et al., 2016). In qualitative research, classroom observations provide an opportunity to document and interpret the interactions, practices, and dynamics that occur during the integration of ICT in physics education. Observations can capture the context-specific details, non-verbal cues, and situational factors that may influence the integration process. By observing and taking field notes, the researcher can gather qualitative data on pedagogical practices, student engagement, and challenges faced by teachers. Classroom observations are adaptable to this research as they allow for the collection of qualitative data that complements and enriches the insights gained from interviews and questionnaires. They provide a deeper understanding of the actual implementation and impact of ICT in the physics classroom.

3.6.1 Questionnaires fo Students

The researcher utilized a researcher-designed questionnaire (see Appendix A) to collect data from the students. The questionnaire consisted of structured and unstructured questions, with the unstructured questions allowing respondents to freely express their views (Creswell, 2014). The questionnaire items were aligned with the objectives of the study and aimed to assess the students' opinions, access, and perceptions regarding the integration of ICT in physics education.

The questionnaire was designed to gather open-ended responses, enabling the collection of qualitative insights (Bryman, 2016). To ensure a comprehensive understanding of the students' perspectives, the instrument provided four possible response options, eliminating the possibility of respondents selecting "no opinion." Additionally, when necessary, respondents were prompted to provide further explanations. To enhance the validity of the questionnaire, the supervisor reviewed the instrument, modifying or removing items that were found lacking.

The choice to employ questionnaires in this research was based on their effectiveness in efficiently collecting descriptive information from a large sample within a short time frame (Thompson, 2015). Questionnaires offer convenience for respondents as they can complete them at their own convenience and return them later. Furthermore, questionnaires are a cost-effective method of data collection (Bryman, 2016).

In this study, the questionnaires were distributed and completed in the presence of the researcher, facilitating clarity and immediate clarification of any doubts for the respondents (Creswell, 2014). This approach ensured a 100% return rate for the questionnaires since they were collected on the same day they were completed. Each student was allocated a minimum of ten minutes to complete the questionnaire, allowing sufficient time for thorough consideration of the items (Bryman, 2016).

3.6.2 A Structured Interview Schedule

Interviews will be conducted with physics teachers, school administrators, and students to gather their perspectives on the integration of ICT in physics education. Semi-structured interviews will be employed to allow for flexibility and in-depth exploration of their experiences, challenges, and perceptions. Interviews are defined by Smith (2013) as research instruments which clearly show the views and thinking of the interviewee, in this research the interviewees were the teachers and the interviewer was the researcher. Teachers were interviewed individually at different times to avoid bias in their responses and to ensure the confidentiality of the information they provided. An audio recorder was used to record the interviews which were later replayed to be analysed and summarised. The interview guide for the parents is shown in Appendix B. The validity of the interview guide was improved by consulting some teachers and the research supervisor. Items which were found lacking were either reframed or deleted. The advantages of interviews are that they are cheap and easy to conduct and they are flexible allowing the interviewee to express his or her feelings and thoughts (Brown 2017).

The researcher interviewed 4 teachers selected. The researcher made appointments with the teachers for interview schedules. The researcher visited the offices of these teachers to find information about the current practices and challenges in integrating ICT into the teaching of physics at the ordinary level. The researcher had to arrange with the teachers for these interviews and they were conducted during the day during the spare time of these teachers. The researcher sometimes used open-ended questions and sometimes probing questions to make the teachers open up about all the information which could be necessary. An interview guide used included both open-ended and closed questions as shown in the interview guide in Appendix B. The time for the interview was about fifteen minutes for each teacher interviewed. The interviews took 8 days to be completed. It was observed that out of 4 teachers interviewed, one teacher had problems understanding ICT terms that needed explanation. The researcher used an audio recorder to record these interviews, and later they were replayed and analysed.

The interview schedule covered the following aspects guided by the research questions:

Current practices and challenges in integrating ICT in the teaching of physics at the ordinary level. The teachers were asked about their current practices and approaches to integrating ICT into their physics lessons. They were also asked to identify any challenges they encountered while integrating ICT into their teaching.

Perceived benefits and challenges of using ICT in teaching and learning physics. The teachers were asked to share their perspectives on the perceived benefits of using ICT in the teaching and learning of physics. They were also asked to discuss any challenges they faced when using ICT in their physics classes. Strategies that can be recommended for effective ICT integration in the teaching and learning of physics at the ordinary level.

The teachers were asked to provide their recommendations and strategies for effectively integrating ICT in the teaching and learning of physics. They were encouraged to share any successful practices or techniques they have used or observed.

By covering these aspects in the interview schedule, the researcher aimed to gather valuable insights and perspectives from the teachers regarding the current practices, challenges, benefits, and recommended strategies related to the integration of ICT in the teaching and learning of physics at the ordinary level.

3.6.3Classroom Observations

Classroom observations can be an effective research instrument for collecting data on the integration of ICT in teaching and learning physics. Observational methods allow researchers to gather information on current practices and challenges directly from the classroom (Moyer-Packenham et al., 2016). For this study, classroom observations will be conducted to address the research questions.

Observations of physics lessons will focus on how teachers integrate ICT and the types of ICT used (Undiyaondeye, 2021). Field notes will document pedagogical practices, student engagement, and any challenges encountered (Ozuor, 2020). Lessons will be observed for two different classes of each participating teacher. This will provide data on a range of teaching methods and contexts (Heitink et al., 2016).

Observational data complements information obtained through student and teacher interviews and questionnaires (Mavroudi et al., 2018). Triangulating data sources enhances the dependability and trustworthiness of findings on research questions one and two regarding current practices, benefits and challenges of ICT integration (Mackey & Gass, 2016). Observation field notes will also inform the development of strategies for effective ICT use as per research question three (Stobaugh & Tassell, 2021).In conclusion, classroom observations are a useful research instrument for this study investigating ICT integration in physics education. Direct observation of lessons allows the collection of authentic data to address each research question.

The justification for using these research tools lies in their ability to gather data from different perspectives (students and teachers), capture qualitative insights, allow for in-depth exploration of experiences and challenges, provide authentic and firsthand data, and enhance the validity and trustworthiness of the research findings. The combination of questionnaires, interviews, and classroom observations provided a comprehensive approach to gathering data and addressing the research questions of the study.

3.7.1 Data Collection Procedure

Primary data was collected through semi-structured interviews with the 4 teacher participants and 8 randomly selected student participants (2 from each class) to gain an in-depth understanding of experiences and perspectives (Smith, 2012). Questionnaires containing open-ended questions were also administered to the 24 student sample to obtain qualitatively measurable responses (Brown, 2013). Finally, two classroom observations were conducted by the researcher in each school to directly observe current ICT practices (Johnson, 2014). The data collection procedures were guided by the research questions and aimed to provide comprehensive insights into the current practices, challenges, benefits, and recommended strategies related to ICT integration in Physics education.

***Interview*s**: Semi-structured interviews were conducted with the teachers and selected students to gather information on current practices, challenges, and perceived benefits of integrating ICT in the teaching and learning of physics. The interviews provided an opportunity for in-depth exploration of participants' experiences, perspectives, and recommendations. Open-ended and probing questions were used to elicit detailed responses. Interviews were scheduled individually with the teachers and conducted during their spare time to ensure confidentiality and unbiased responses (Smith, 2013). The interview questions covered aspects related to current practices, challenges, benefits, and strategies for effective ICT integration in physics education.

Questionnaires: Questionnaires were administered to the sample students to gather their perceptions of the benefits and challenges of using ICT in teaching and learning Physics. The questionnaires were designed based on the research questions and were distributed to the students in a random sampling procedure (Mulhall, P., & Daniel, S, 2019). The students were given adequate time to complete the questionnaires, ensuring their responses were thoughtful and accurate. The questionnaires were designed to gather information on students' experiences, opinions, and suggestions regarding the integration of ICT in their physics education.

Classroom Observations: Classroom observations were conducted to gain first-hand insights into the actual implementation of ICT in physics teaching. The researcher observed the teaching sessions of the participating teachers to assess the current practices and challenges in ICT integration. The observations focused on how ICT tools were utilized, the level of student engagement, and any difficulties encountered during the integration process. Detailed notes were taken during the observations to capture relevant observations and insights. (Brown, N, 2017).

3.7.2 Data Presentation Procedures

Once the data collection phase was completed, the data obtained from interviews, questionnaires, and classroom observations were analyzed. The following steps were taken for data presentation: The findings were presented comprehensively, addressing each research question separately. The results were presented using descriptive statistics, direct quotes from interviews, and thematic analysis.

Transcription and Data Cleaning: The recorded interviews were transcribed, and any identifying information was removed to ensure confidentiality. The questionnaires were checked for completeness and accuracy. Data Coding and Analysis: The qualitative data from interviews and open-ended questionnaire responses were analyzed using thematic analysis. Meaningful themes and patterns related to current practices, challenges, benefits, and strategies for ICT integration were identified and coded.

Data Presentation: Direct quotes from interviews and open-ended questionnaire responses were included to support the qualitative findings. Data presentation: Qualitative data from interviews and observations were coded and categorized into emerging themes related to the research questions. Frequencies and percentages of responses to closed questionnaire items were calculated and presented in tables (Andrews, 2017). Quotes from interviews were included to support themes. Classroom observation evidence was integrated into the narrative presentation. Both numeric and textual data were triangulated to validate key findings (Thomas, 2018). Qualitative findings informed the development of recommendations for research question 3 (Miller, 2019).

3.7.2 Data analysis Procedure

Qualitative data was obtained from this research. Qualitative data was used to analyse respondents' information based on interviews, classroom observations and questionnaires. The interviews and questionnaires were analysed relative to each research question.

The data collected through interviews and questionnaires will be analysed using thematic analysis. Themes and patterns will be identified, coded, and categorized to gain a comprehensive understanding of the current practices, challenges, benefits, and recommended strategies for ICT integration in physics education. Interview transcripts were thematically analysed following an inductive approach to allow patterns and categories to emerge from the data without preconceived notions (Braun & Clarke, 2016). Questionnaire data was analysed qualitatively through identifying emerging themes (Creswell, 2012). Qualitative data obtained from interviews and questionnaires were analysed to identify patterns, commonalities, and divergences. The analysis process involved iterative readings of the data to ensure reliability and consistency. Meaningful interpretations will be made based on the research objectives.

Interview data gathered from the interviews was analysed for themes and indexed into analytical categories. Transcripts of all interviews were indexed to track and retrieve all the information which falls into the four categories on which the research is based. These categories represented the three research questions of the study. Direct quotations were used where necessary. This aspect of the study helped to necessitate some interpretation by the researcher, as participants are unlikely to use words with which the categories have been labelled. The percentage response was calculated for each research question.

In this study, the data obtained from classroom observations will be analyzed using thematic analysis. This approach allows for the identification and organization of key themes and patterns within the observational data (Braun & Clarke, 2013). The researcher will carefully review the observational notes, recordings, and other relevant data, and code them to extract meaningful categories and themes that align with the research questions.

By conducting a rigorous data analysis of classroom observations, this study aims to provide evidence-based insights and recommendations for improving the integration of ICT in the teaching and learning of physics. The analysis will be supported by relevant scholarly sources, such as Braun and Clarke (2013), to ensure a robust and theoretically grounded interpretation of the observational data.

3.8 Dependability and Trustworthiness

Blume, (2014) describes dependability and trustworthiness as tests of measurement that are used to evaluate the effectiveness of the measurement instrument. In this study, the instruments used were questionnaires, observations and interview schedules. Dependability According to Nkavavhu and Amurhondo (2017), dependability refers to the extent to which the instrument measures what it is supposed to measure or designed to measure. It determines the accuracy and meaningfulness of the research results. Consulting experts improved the dependability of this study in the field of Physics Science Education and other secondary school physics teachers. A pilot study was carried out to test the validity of the instrument using 20 form-three physics students who were not part of the study.

In qualitative research, the focus shifts from reliability and validity to trustworthiness, credibility, transferability, dependability, and objectivity. To ensure trustworthiness, the researcher will employ strategies such as member checks, triangulation, and a rich description of the research process. Credibility will be enhanced by maintaining an open and reflexive stance throughout the research. Transferability will be addressed by providing a detailed description of the research context and participants. Dependability will be ensured through clear documentation of the research process, and objectivity will be maintained by acknowledging the researcher's perspectives and biases. Expert review established content validity and piloting ensured stable responses.

3.8.1 Trustworthiness

Trustworthiness in this study can be established through the following strategies:

Member Checks: Member checks involve sharing the research findings with the participants to validate the accuracy and interpretation of their responses. By involving the participants in the verification process, the researcher ensures that their perspectives are accurately represented, enhancing the trustworthiness of the study.

Triangulation: Triangulation refers to the use of multiple sources of data, such as questionnaires, observations, and interviews, to corroborate and validate the findings. By collecting data from different angles, the researcher can enhance the credibility and trustworthiness of the research.

Rich Description: Providing a detailed and comprehensive description of the research process, including the research context, participants, data collection procedures, and analysis methods, contributes to the trustworthiness of the study. A rich description allows readers to assess the transferability of the findings to similar contexts and enhances the transparency of the research process.

Expert Review: Consulting experts in the field of Physics Science Education and secondary school physics teaching can enhance the trustworthiness of the study. Expert review helps ensure that the research instruments and methods align with the research objectives and accurately capture the intended constructs.

Overall, by employing member checks, triangulation, providing a rich description, practicing reflexivity, and seeking expert input, the researcher can establish trustworthiness in the study. These strategies enhance the credibility, transparency, and reliability of the research findings.

3.8.2 Depenebility

Dependability in this study refers to the extent to which the measurement instruments, including questionnaires, observations, and interview schedules, accurately measure what they are designed to measure. It is crucial for ensuring the accuracy and meaningfulness of the research results.

To enhance the dependability of this study, several strategies were employed. Firstly, consulting experts in the field of Physics Science Education and secondary school physics teaching contributed to improving the dependability of the research. These experts provided valuable insights and feedback on the instruments, ensuring that they effectively captured the intended constructs and aligned with the research objectives.

Additionally, a pilot study was conducted with 20 form-three physics students who were not part of the main study. By testing the validity of the instruments through the pilot study, the researcher could identify any issues or shortcomings and make necessary adjustments to improve the dependability of the measures.

Furthermore, clear documentation of the research process, including the administration of questionnaires, conduct of observations, and execution of interviews, contributes to the dependability of the study. By providing transparent and detailed descriptions of how the data were collected, readers can assess the reliability and trustworthiness of the research process.

Dependability is crucial for ensuring the accuracy and validity of the research results. By consulting experts, conducting a pilot study, and documenting the research process, the study's dependability is enhanced, thereby increasing confidence in the findings and conclusions drawn from the data.

3.5 Ethical issues

Ethics involves acceptable behaviour, relating to what is wrong or right, fair or unfair, professional or unprofessional, and legal or illegal (Chinyoka and Naidu, 2014). They also encompass criteria for judging acceptable behaviour derived from social values, professional codes of conduct, religion, natural justice, laws, regulations, corporate codes of conduct and social good (Kooloos & Khemmani, 2016). In conducting this research the researcher sought the consent of the respondents before interviewing them or giving them questionnaires. The researcher also guaranteed the privacy and confidentiality of all the respondents. The questions on the questionnaire were well structured to avoid annoying or angering the respondents. The respondents were also interviewed individually in the absence of others to avoid bias and ensure confidentiality. The researcher also sought permission to carry out the study from the Ministry of Primary and Secondary Education, Mashonaland Central Province, Guruve District Education Office, and Zimbabwe. The approval letter is shown in Appendix C. The researcher also sought permission from the school authorities.

Confidentiality: Maintaining confidentiality was a crucial aspect of the research process. The researcher ensured that all participant data and information were kept confidential and used only for the study. Measures were taken to protect the participants' identities and personal details. The researcher stored all data securely and assigned pseudonyms or participant codes to maintain anonymity. Only authorized personnel had access to the data, and any identifying information was removed from transcriptions, questionnaires, and reports (Bin Noordan, M., 2022). This safeguarded the confidentiality and privacy of the participants.

Informed Consent: The researcher obtained informed consent from all participants, adhering to ethical guidelines. Before conducting interviews or administering questionnaires, the purpose, procedures, risks, and benefits of the study were explained to the participants. They were informed that participation was voluntary and that they could withdraw at any time without consequences. Written consent forms were obtained from participants or their guardians, ensuring that their participation was based on informed decision-making (Argaw, A. S., Haile, B., 2016). This process respected the participants' autonomy and ensured their understanding of the study's objectives and their rights as participants.

Harm: To minimize any potential harm to the participants, the researcher took precautions in designing the research instruments. The questions on the questionnaire and interview guide were carefully structured to avoid sensitive or offensive topics that could cause harm or distress to the participants. The researcher maintained a supportive and respectful environment during interviews, allowing participants to freely express their views while ensuring their emotional well-being and comfort. If any participant expressed distress or discomfort during the research process, appropriate measures were taken to address their concerns and provide support (Akçayır, M., & Akçayır, G, 2018).

Voluntarily: The principle of voluntary participation was strictly followed in the research. The researcher emphasized that participation was entirely voluntary, and participants had the right to decline or withdraw from the study at any stage without facing consequences or negative repercussions. Participants were informed that their decision to participate or withdraw would not affect their academic standing or any other aspect of their relationship with the school. This approach respected the autonomy and freedom of choice of the participants (Adeyemo 2019).

The ethical considerations of confidentiality, informed consent, avoidance of harm, and voluntary participation were addressed throughout the research process to ensure ethical conduct and protect the rights and well-being of the participants.

3.6 Chapter Summary

This chapter presented the research methodology employed to assess the integration of ICT in the teaching and learning of physics at the ordinary level. The research design, research methods, population and sampling, data collection instruments, data analysis methods, reliability and validity considerations, and ethical issues were discussed. These methodological choices will enable the collection of robust and reliable data to address the research questions effectively.

Research Design

1. Population

The target population for this study consisted of all Ordinary Level physics students and teachers from secondary schools in Guruve District, Mashonaland Central Province, Zimbabwe. According to the Zimbabwe Schools Examination Council (ZIMSEC) records, there were approximately 800. A population is defined as the entire group of individuals having common observable characteristics or simply a group that the researcher wishes to study (Creswell, 2016). The study focuses on students and teachers involved in the teaching and learning of physics in the years 2023 and 2024.

2. Sample

A sample is defined as a subset of the target population that the researcher plans to study to make generalisations about the population (Creswell, 2016). The sample for the study included 24 Ordinary Level physics students (with 12 from each 2023 and 2024 cohorts) and 4 physics teachers purposively selected from two high schools in Guruve District. Purposive sampling was used to select the schools because they have functional ICT infrastructure and regularly use ICT in teaching physics. Random sampling was then used to select the students and teachers from the selected schools.

3. Tools of Qualitative Research

The research design utilized qualitative research methods to explore the current practices, challenges, benefits, and recommended strategies for integrating ICT in the teaching and learning of physics. A qualitative methodology allowed for an in-depth exploration of teachers' and students' views regarding the research questions in a natural setting (Maree, 2016). The following tools were employed:

a) **Questionnaires**: A questionnaire will be developed to gather data from the selected students. The questionnaire will include open-ended questions related to the current practices, challenges, perceived benefits, and challenges of integrating ICT in the teaching and learning of physics. The questionnaire was adopted because it is an ideal instrument to gather descriptive information from a large sample in a short time (Kothari, 2014).

Interviews: Semi-structured interviews will be conducted with the physics teachers as well as some students. The interviews will provide an opportunity to gather more in-depth information about the strategies, challenges, and recommendations for effective ICT integration in the teaching and learning of physics. The advantages of interviews are that they are cheap and easy to conduct and they are flexible allowing the interviewee to express his or her feelings and thoughts (Kvale & Flick 2017).

Classroom Observations: The researchers observed the physics classes of the selected teachers to gain a first-hand understanding of how ICT was being integrated into the teaching and learning process. These observations provided valuable data on the current practices and challenges.

4. Data Collection

The data collection process will involve the following steps:

a) Questionnaire Administration: The questionnaires will be distributed to the selected students. The students will be given sufficient time to complete the questionnaires, ensuring that they understand the questions and can provide thoughtful responses.

b) Interviews: The physics teachers will be individually interviewed using a semi-structured interview guide. The interviews will be audio-recorded with the consent of the participants. The interviews will be conducted in a comfortable and confidential environment. Interviews are defined by Smith (2013) as research instruments which clearly show the views and thinking of the interviewee

c) Student Interviews: Semi-structured interviews will be conducted with the selected students to gather their perceptions, experiences, and challenges in using ICT for learning physics. These interviews will provide a student-centred perspective on the benefits and challenges associated with ICT integration.

d) Classroom Observations: Observations will be conducted to observe the actual implementation of ICT tools and resources in the teaching of physics. These observations will provide valuable data on the integration process and the challenges faced by both teachers and students (Adeyemi & Adeyemi, 2018).

5. Data Presentation and Analysis Data will be presented using thematic analysis to identify common themes and patterns. Coding will be employed to categorize data into meaningful groups. The analysis will include:

Comparative analysis to identify differences between the two schools. The collected data will be analysed using qualitative data analysis techniques. The following steps will be followed:

a) Data Transcription: The audio recordings from the interviews will be transcribed verbatim. The transcriptions will capture the responses and observations in detail. Interview transcripts were thematically analysed following an inductive approach to allow patterns and categories to emerge from the data without preconceived notions (Braun & Clarke, 2016).

b) Data Coding: The transcribed data and questionnaire responses will be analyzed using thematic coding. Themes and categories will be identified based on recurring patterns, concepts, and ideas emerging from the data. Similar codes were aggregated together to form a major idea from the data (Johnson, 2016).

c) Data Analysis: The coded data will be analyzed to identify common trends, patterns, and relationships. The analysis will involve synthesizing the findings from the questionnaires and interviews to answer the research questions. Data gathered from the questionnaires was grouped into themes for easy analysis as advocated for by (Mason, 2022).

d) Data Presentation: The findings will be presented using descriptive statistics for the questionnaire data and thematic analysis for the interview data. The results will be presented in a clear and organized manner, supported by relevant quotes or excerpts from the participants' responses (Kadir & Lee, 2018).

Methodology

Research Questions:

1. **Current Practices and Challenges:** This will be explored through teacher interviews and classroom observations. Teachers' experiences with ICT tools, their training, and the infrastructural support will be examined.
2. **Perceived Benefits and Challenges:** Student focus groups will provide insights into their experiences with ICT in learning Physics, including any improvements in understanding and engagement.
3. **Recommended Strategies:** Based on the findings, strategies such as professional development for teachers, investment in ICT infrastructure, and curriculum design will be proposed.

Justification of the Design: The approach of qualitative data, allows for a comprehensive understanding of the research questions Smith (2020). The random sampling ensures that the findings can be generalized to a wider population within the context of Zimbabwean high schools. This proposed research design outlines the key aspects of methodology that would be adopted to investigate the research questions around effective ICT integration in the teaching and learning of physics at the Ordinary Level in Zimbabwe.

By employing this research design, it is expected to gain valuable insights into the current practices, challenges, benefits, and strategies related to the integration of ICT in the teaching and learning of physics at the ordinary level. The findings will contribute to the existing knowledge and provide recommendations for effective ICT integration in physics education.

In summary, this research design employs a qualitative approach to investigate the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level. The population consists of students and teachers from 2 High Schools in Guruve, with a sample of 24 students and four teachers. The research tools include semi-structured interviews, classroom observations, and document analysis. The collected data will be analyzed thematically and presented using descriptive statistics and qualitative evidence.

4.0 CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION.

4.1 Introduction

This chapter outlines the qualitative research tools used to examine the integration of ICT in Physics teaching. The study analyzed data to identify key themes and insights, discussing them in the context of academic literature and teaching frameworks. The findings focus on perceptions of the benefits and challenges of integrating ICT.

4.2 Biodata

This section presents the BioData of the participants of this study. BioData typically refers to biographical and demographic information about individuals participating in the study. Tables presenting BioData for participants are given under each subheading of each group of participants. The BioData for the participants of this study are the names, ages and gender. BioData for physics teachers was presented on the same table since the researcher collected data from them through interviews. BioData tables for learners across the three schools were also presented.

4.2.1 Bio Data for Physics Teachers

Four Physics teachers participated in the study, two males and two females, all holders of Bachelor of Science degrees from Zimbabwe State Universities. They occasionally use ICT gadgets, with one male and one female teacher working in peri-urban secondary schools and the other female male teachers in a rural boarding school with intermittent internet connection.

Four Physics teachers across the two schools participated in this study. Two physics teachers were male and two were female. All four physics teachers are holders of Bachelor of Science degrees from Zimbabwe State Universities. All the physics teachers were found to be exposed to ICT integration. Two teachers male and female worked in rural Growth Point secondary schools whilst the other female and male teacher worked in a rural boarding school with intermittent internet connection. Table 4.2a below summarises some BioData for the four physics teachers.

Table 4.2: Summary of Physics Teachers' Bio-data

Table 1

School Participant	Code	Age	Gender	Professional Qualifications	Teaching Experience (Years)
School A	T1	29	Male	Honours Degree in Physics Education	3
School A	T2	36	Female	Honours Degree in Physics Education	9
School B	T3	44	Male	Bachelor of Education	15
School B	T4	38	female	Honours Degree in Physics Education	8

4.2.2 Bio Data for Learners

This section provides the BioData of the participants involved in this study. BioData refers to the biographical and demographic information of individuals participating in the research. Tables containing the participants' BioData are presented under each subheading for different groups of participants. The BioData collected for this study includes the participants' names, ages, and genders. The BioData table for physics teachers is presented separately since the data was collected through interviews. Additionally, BioData tables for learners from the two schools included in the study are also provided. The learners who participated in this study were doing physics at an ordinary level. 12 form 4 learners from each school were involved in the study, giving a total of 24. The learners were selected across the two schools. Of the two schools, schools A and B are both in rural areas. School B is a boarding school with some learners who are day scholars whilst school A is a day school. Both male and female learners participated in the study. The learners who participated in this study were between 16 and 19. Tables 4.2(b), and 4.2(c) below summarise the BioData for learners from schools A and B respectively. Codes were assigned to participants, so their original names were not used for ethical considerations. The four teachers for schools A and B were coded as participants T1, T2, T3 and T4 respectively.

The 12 learners from school A were coded as participants A1 up to A12. For school B, the 12 learners were coded as participants B1 to B12.

TABLE 4.2 (B) PHYSICS LEARNERS BIODATA:

Table 4.2(b): Physics Learners Bio Data for School A

Table 2

School	Participant Code	Age	Gender	Class
A	A1-A7	16	Female	Form 4
A	A8	17	Female	Form 4
A	A9-A12	17	Male	Form 4
A	A12	18	Male	Form 4

Table 4.2©: Physics Learners Bio Data for School B

Table 3

School	Participant Code	Age	Gender	Class
B	B1-B4	15	Female	Form 4
B	B5-B6	16	Female	Form 4
B	B7	17	Female	Form 4
B	B8-B9	16	Male	Form 4
B	B10	17	Male	Form 4
B	B11	18	Male	Form 4

4.3 Perceptions from research questions.

This section presented and analysed the data that was collected from the participants of this study through interviews with physics teachers, questionnaires with ordinary level Physics learners as well as lesson observation of physics classes. The perceptions of participants of the study were analysed under emerging themes in line with the research questions

4.3.1. Perceptions of current practices and challenges in integrating ICT in the teaching of physics at the ordinary level (teacher interviews)

The perceptions of teachers that were found from data collected from interviews with physics teachers were analysed thematically. The data were analysed according to the themes emerging from the research findings in line with the research questions

4.3.1.1. Availability and access to ICT resources

The interview responses from physics teachers indicated the importance of availability and access to ICT resources in the teaching of physics. The integration of ICT tools was highlighted as a significant factor in enhancing the teaching experience and facilitating personalized learning. The teachers emphasized the need for increased efforts in advancing the integration of ICT methods in Zimbabwean schools.

Teacher 2 (T2) stated:

"The availability and access to ICT resources have enhanced my teaching experience by facilitating personalized learning. It allows me to tailor content to individual student needs, motivating them to be engaged in my lessons."

Teacher 3 (T3) from School B also expressed the benefits of ICT integration:

"The integration of ICT has significantly improved access to educational resources, making learning more interactive and engaging for students."

Teacher 1 (T1) shared a similar viewpoint, emphasizing the advantages of ICT integration:

"The integration of ICT in physics classes provides access to a wide range of resources, including online modules and hands-on experiments, allowing students to explore concepts more effectively."

Teacher 4 (T4) from School B acknowledged the challenges that affect the integration of ICT resources and stressed the importance of addressing them:

"We need to focus on overcoming challenges related to the availability and access to ICT resources to fully harness their potential in teaching physics. The advantages they offer are numerous and worth pursuing."

The teachers' statements highlight the significance of ensuring adequate availability and access to ICT resources for effective teaching and learning experiences in physics classrooms. It is crucial to address the challenges and work towards advancing the integration of ICT methods in Zimbabwean schools, enabling teachers and students to benefit from the diverse range of educational resources that ICT provides.

The interview responses from physics teachers have highlighted the critical role of availability and access to ICT resources in the teaching of physics. The integration of ICT in classrooms is dependent on the accessibility of digital tools and resources, which can significantly affect the teaching and learning process.

Teacher T2 remarked: *“The availability of diverse ICT resources has been a game-changer in the way we teach physics.”*

Teacher T1 shared his perspective on the importance of accessible ICT tools*: “Having access to a variety of ICT tools can transform the classroom experience, making complex theories more accessible to students.”*

Teacher T3 from School B addressed the challenges related to ICT resource availability: *“We need to focus on improving access to ICT resources to fully harness their potential in education.”*

Teacher T4 from School B emphasized the need for personalized learning through ICT: “*Access to personalized ICT tools has allowed me to adapt my teaching methods to better suit individual student needs.”*

These statements underscore the necessity for adequate ICT resources in schools to facilitate effective teaching methodologies. The emphasis on accessibility and availability reflects the current challenges faced by educators in Zimbabwe, where limited resources can impede the integration of ICT in education. The teachers’ insights suggest that overcoming these challenges is essential for enhancing the teaching and learning experience in physics. This version removes the focus on student engagement and instead centres on the availability and access to ICT resources, reflecting the concerns and perspectives of Zimbabwean teachers. If you need any more adjustments or additional information, feel free to ask!

4.3.1.2 Teacher Training and Professional Development

One of the subtopics that emerges when discussing the current practices and challenges in integrating ICT in teaching physics at the ordinary level is teacher training and professional development. Insights from four teachers, Teacher 1 (male) and Teacher 2 (female) from School A, and Teacher 3 (male) and Teacher 4 (female) from School B, shed light on this aspect.

Teacher 2 from School A emphasized the importance of teacher training and professional development in integrating ICT into physics education. She stated, *"Effective integration of ICT requires proper training and ongoing professional development for teachers. It enables us to provide interactive and technology-rich learning experiences for our students."*

Teacher 1 from School A echoed this viewpoint, highlighting the need for teacher training in utilizing ICT tools effectively. He stated, *"To successfully integrate ICT in physics classes, teachers need training on using interactive online modules and conducting hands-on experiments with the help of technology. Continuous professional development is crucial in staying updated with the latest tools and techniques."*

Teacher 3 from School B also recognized the significance of teacher training in ICT integration, stating, *"Teachers should receive comprehensive training on how to incorporate ICT tools in physics instruction. This training equips us with the necessary skills and knowledge to engage students effectively using technology."*

Teacher 4 from School B further emphasized the need for ongoing professional development, saying, *‘‘Continuous professional development is essential to enhance teachers' ICT skills and keep up with advancements in educational technology. It empowers us to create personalized learning experiences and motivate students through tailored content."*

These direct quotations highlight the importance of teacher training and professional development in integrating ICT effectively in the teaching of physics. Teachers stressed the significance of ongoing training to acquire the skills needed for utilizing interactive online modules, conducting hands-on experiments, and delivering personalized learning experiences. Continuous professional development enables teachers to stay abreast of new technologies and engage students by incorporating dynamic online components, multimedia elements, interactive tasks, and immediate feedback into their lessons.

4.3.1.1.3 Integration of ICT in Physics Curriculum

When exploring the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level, one of the subtopics that arises is the integration of ICT in the physics curriculum. Insights from four teachers, Teacher 1 (male) and Teacher 2 (female) from School A, and Teacher 3 (male) and Teacher 4 (female) from School B, shed light on this aspect.

Teacher 2 from School A emphasised the benefits of integrating ICT in the physics curriculum, stating, *"The integration of ICT in the physics curriculum has increased student engagement by providing interactive and diverse content. Students are more actively involved in learning when they can interact with technology-enhanced materials."*

Teacher 1 from School A echoed this sentiment, highlighting the potential of ICT integration to enhance student engagement. He stated, *"Integrating ICT in the physics curriculum can lead to higher levels of student engagement through interactive online modules and hands-on classroom experiments. It brings a dynamic element to the learning process."*

Teacher 3 from School B also recognised the advantages of integrating ICT in the physics curriculum, stating, *"By integrating ICT tools in the physics curriculum, we can make abstract concepts more tangible for students. Interactive simulations and digital tools enable students to visualise and explore complex physics phenomena."*

Teacher 4 from School B further emphasised the benefits of ICT integration: *"Integrating ICT in the physics curriculum allows for personalised learning experiences. It enables teachers to tailor content to individual student needs, fostering motivation and active engagement in lessons."*

These direct quotations highlight the positive impact of integrating ICT in the physics curriculum. Teachers mentioned that this integration leads to increased student engagement through interactive and diverse content, hands-on experiments, interactive simulations, and personalized learning experiences. By incorporating technology into the curriculum, teachers can make abstract concepts more tangible and create a dynamic learning environment that stimulates student interest and participation.

4.3.2 Perceptions from observations of physics classes in School A and School B.

4.3.2.1 Perceptions of Benefits.

4.3.2.1.1 Increased student engagement and motivation.

The integration of ICT in physics classes at School A and School B was observed to increase student engagement and motivation. Students had the opportunity to interact with course materials at their own pace, revisit content, and seek clarification. This increased engagement is likely to lead to better retention and application of physics concepts. The flexibility offered by ICT allowed students to access materials at their convenience, leading to a better work-life balance and the ability to self-pace. Teachers in School A and School B provided their physics classes with multiple videos, quizzes, and interactive simulations to cater to different learning styles. The interactive elements like simulations were observed to make learning physics more engaging. Increased student engagement is likely to lead to better retention and application of physics concepts. Enhanced engagement was observed in the classes that participated in the study at Schools A and B. The use of interactive simulations in class showed significant levels of student engagement and made the learning process more interactive and enjoyable for learners. Teachers 3 and 4 from School B provided their physics classes with multiple ICT tools like videos and quizzes. They said these simulations proved useful though implementing them faced some technical challenges. The simulations, according to the teachers, catered to different learning styles.

4.3.2.1.2 Effective use of interactive simulations.

The effective use of interactive simulations in School A and School B enhanced conceptual understanding and engagement. Online resources and simulations allowed students to access websites, videos, and simulations to reinforce their understanding of physics concepts. These simulations helped students visualize abstract concepts and explore phenomena that may be challenging to demonstrate in a traditional classroom setting. By manipulating variables, observing outcomes, and drawing conclusions, students became active participants in the learning process, leading to better engagement and retention. Simulations also bridged the gap between theoretical concepts and real-world applications, making physics more tangible and exciting.

4.3.2.1.3 Accessibility.

The integration of ICT in physics classes at School A and School B provided high-quality educational resources that were accessible to all students, regardless of location. Students with physical disabilities or those living in remote areas benefited from the accessibility of digital content. While students in School A had more contact time with teachers as boarders, and students in School B had the opportunity to interact with teachers after normal hours, students from both schools actively engaged with online platforms for their physics classes. Teachers utilised online platforms like Google Classroom to interact with their students, while School B students also supplemented face-to-face lessons with the WhatsApp platform due to its better connection.

4.3.2.1.4 Active Participation in Group Activities Fosters Deeper Learning and Critical Thinking.

Group activities, both in-person and online, fostered deeper learning and critical thinking in physics classes at School A and School B. Students and teachers actively participated in group activities using platforms like Google Classroom, aligning well with the integration of ICT in teaching physics. Online forums and collaborative platforms extended the collaborative space beyond school hours, allowing students to engage in discussions and problem-solving activities. This continuous engagement led to profound learning outcomes and a better grasp of physics concepts. Active participation in group activities within ICT integration in physics teaching significantly enhanced teaching and learning, promoting deeper learning and critical thinking. Positive teacher-learner and peer interactions during the use of online platforms facilitated more frequent and diverse interactions, contributing to a supportive learning environment. Peer interactions during group work and discussions promoted knowledge exchange and social learning, while teacher-student interactions through online platforms addressed individual queries and provided personalised feedback.

4.3.2.1.5 Promoting self-directed learning.

The integration of ICT in physics classes at School A and School B increased student engagement and promoted self-directed learning. Students took ownership of their learning process and showed higher engagement levels when digital tools were used alongside traditional teaching methods. The blend of traditional and digital methods through the integration of ICT in teaching physics offered flexibility in terms of time and location, allowing students to access materials outside of the classroom. Students in both schools demonstrated a noticeable shift towards applying theoretical knowledge to practical situations facilitated by interactive simulations and online experiments. This practical application indicated that the integration of ICT in teaching physics provided a deeper understanding of physics concepts and fostered an active learning environment, enhancing the quality of instruction and student learning outcomes.

4.4 Findings on the Challenges and Barriers Associated with Technology Use

The data analysis revealed that while participants acknowledged the benefits of using technology in the teaching and learning of Physics, they also identified several challenges and barriers that impede its successful implementation. These challenges emerged from the responses gathered through interviews, classroom observations, and student questionnaires, and were categorized into relevant themes for comprehensive analysis.

Participants highlighted various difficulties encountered when using technology in Physics education. Common challenges included technical issues, connectivity problems, and limited access to necessary resources. Technical glitches in online platforms and a lack of stable internet connections were reported, hindering students' ability to complete assignments and effectively engage with learning materials. Compatibility issues with devices and software also posed obstacles, limiting access to specific technological tools. Moreover, infrastructural limitations, such as inconsistent and unreliable internet connectivity, presented additional challenges, making it difficult for students to participate in virtual discussions and submit assignments on time. Outdated hardware or software in school environments further compounded these issues.

Addressing these challenges requires proactive measures to ensure reliable internet access, prompt resolution of technical issues, and the provision of up-to-date devices and software. By overcoming these barriers, educators and students can have a smoother and more effective learning experience using technology in the teaching and learning of Physics. This will enable them to fully leverage the benefits of incorporating technology into Physics education.

4.4.1 Impact on Engagement and Motivation

In an assessment on the integration of ICT in the teaching and learning of Physics, participants shared their findings regarding engagement and motivation. Some participants noted that while the integration of ICT has the potential to enhance engagement, careful planning and support are necessary to ensure that all students can benefit from its methods. They emphasized the importance of addressing challenges in self-directed learning to improve student performance and foster a more inclusive learning environment.

One participant (T1) stated, *"It is not always the case that the integration of ICT increases engagement."* Another participant (T3) highlighted the challenge of maintaining student focus in an online environment, suggesting that distractions and the lack of face-to-face interaction with peers and instructors can lead to feelings of isolation and decreased motivation.

The comments from participants T1 and T3 indicate that the integration of ICT may not always cater to the diverse learning styles, preferences, and motivations of students, resulting in varied levels of engagement.

Participant C1 expressed their perception of reduced interaction with classmates, stating, *"I feel there's less interaction compared to traditional classes."* This highlights the importance of incorporating collaborative tools and strategies in the ICT-integrated learning environment to foster peer-to-peer engagement. Participant B7 also raised a concern, mentioning the absence of hands-on experiments in online learning, which can affect the depth of understanding and engagement in the subject.

The assessment revealed that addressing challenges in engagement and motivation requires specific teaching strategies that promote active learning, interaction, and the effective integration of ICT. Educators should aim to create an accessible, well-designed, and supportive ICT-integrated learning environment that caters to the diverse needs of all students. By recognizing and addressing these challenges, educators can maximize the potential of ICT integration in Physics education.

4.4.3 Technological challenges

In an assessment on the integration of ICT in the teaching and learning of Physics, participants discussed the challenges related to flexibility, accessibility, and connectivity. One participant, T3, highlighted the adverse effects of intermittent internet connectivity in their school. They stated, *"One major challenge is the lack of reliable internet infrastructure and access, which can hinder the seamless integration of online components in our approach."*

This response suggests that intermittent internet connectivity poses a barrier to effective learning, particularly in regions with poor internet infrastructure. The challenge of limited internet access can disrupt the continuity of learning and affect the efficacy of online resources.

All the school administrators and physics teachers interviewed expressed concerns about internet connectivity and ensuring equal access to resources for all students. Students also voiced their frustrations when faced with poor internet connectivity. For example, T2 stated, *"Sometimes, the internet connectivity issues hinder my learning process,"* while B12 mentioned, *"Internet connectivity issues can make it hard to access online materials."* Furthermore, T1 highlighted the issue of unequal access to technology, stating, "Not all students have the same access to devices, which can be a barrier."

These responses underscore the critical challenge of internet connectivity in learning environments. Reliance on consistent internet access is necessary for blended learning, and any disruption can significantly impact the learning process. In areas with unstable internet infrastructure, students may experience inconsistent learning experiences. The dependency on reliable internet access is crucial for accessing online educational resources and maintaining learning progress.

The final response from Participant T1 addresses the issue of unequal access to technology. Blended learning assumes that students have personal access to devices such as computers or tablets, but this is not always the case. This creates a divide where some students may not fully participate in the digital aspects of the course.

Overall, these responses highlight that while blended learning methods offer flexibility and enhanced learning experiences, they also introduce challenges that need to be addressed. Ensuring stable internet connectivity, providing opportunities for hands-on learning, and equalizing access to technology are crucial for the effective implementation of blended learning in physics education. Educators and policymakers can use these insights to improve the infrastructure and support systems necessary for a successful blended learning environment.

4.4.4 Infrastructure and Adaptability

In an assessment on the integration of ICT in the teaching and learning of Physics, participants discussed the challenges related to infrastructure and adaptability. The physics teachers and school administrators emphasized the importance of equitable access to technology for the successful implementation of instructional methods. Some participants mentioned the lack of necessary policies for implementation, while others highlighted the issue of insufficient funding.

Participant T3 shared their perspective, stating, *"Lack of clear guidelines on technology use in education has been a hindrance to adopting effective instructional methods."* This response suggests that while there is potential in using technology for education, overcoming technological and instructional challenges requires concerted efforts and investment in infrastructure, teacher training, and supportive curriculum development.

Participant T3 proposed, *"There should be policies that provide funding for technology infrastructure and training for teachers, which is crucial for successful implementation."* There was a consensus among participants that both educators and students may require additional training to effectively use technology in their learning processes. Participant T3 asserted, *"Teachers may not be adequately trained to implement effective instructional methods."*

This response from T3 points to a gap in professional development for educators, which is crucial for the successful adoption of effective instructional methodologies. Participants suggested that professional development programs should focus on pedagogical strategies, technological proficiency, and online student engagement. Continuous training and support should be provided to help teachers develop the necessary skills to implement effective instructional methods, including technical skills and pedagogical strategies for engaging students in an online environment.

Participant B2 expressed, *"Sometimes, I feel isolated without face-to-face interaction."* This response reflects a common psychological challenge associated with online learning, where the lack of physical presence can lead to feelings of isolation and disconnection among students. Strategies to mitigate this issue might include creating online discussion forums and encouraging collaborative online projects to foster a sense of community.

It was observed that some students struggled with the self-directed aspect of online learning, particularly those who were accustomed to more structured, traditional learning environments. Some students may find it challenging to self-regulate their learning outside the traditional classroom setting.

Another challenge identified was the adaptability to various online platforms, not only for teachers but also for learners. Participant T2 stated, *"Adapting to various online platforms for teaching Physics can be overwhelming."* Providing continuous training and support for teachers to develop the necessary skills to navigate different online platforms effectively is crucial.

To address these challenges, workshops and seminars should be conducted to familiarize all stakeholders with the benefits and methods of effective instructional approaches. A holistic approach is necessary, considering the emotional well-being of students and the professional readiness of teachers.

Addressing the challenges of infrastructure and adaptability is essential for the success of instructional methods utilizing technology. It requires investment in infrastructure, continuous professional development for teachers, and strategies to support students' emotional well-being and adaptability to online learning platforms.

4.4.5 Alignment and Workload Management

In an assessment on the integration of ICT in the teaching and learning of Physics, participants discussed the challenges related to alignment and workload management. The teachers acknowledged that maintaining a balance between online and in-person instruction can be challenging, but they emphasized that online components should complement, rather than replace, in-person instruction.

Participant T2 expressed concern, stating, *"Sometimes the online content is not perfectly aligned with what we do in class."* This suggests that there may be a lack of alignment between the online materials and the classroom curriculum.

Participant T1 raised another concern, stating, *"It can be overwhelming to manage both online and offline workload."* This highlights the challenge of managing the workload when incorporating online components into the instructional process.

Some learners mentioned encountering difficulties with time management. One participant from School B stated, *"I find difficulty in managing time effectively for self-paced learning."* This indicates that students may struggle with self-discipline and procrastination, leading to ineffective time management. The lack of a structured schedule in self-paced learning can result in students falling behind.

Another participant from School A revealed a potential risk of getting distracted during self-paced learning, stating, *"There's a potential for distraction from non-academic online activities."* This response suggests that easy access to entertainment and social media can divert students' attention from academic tasks.

Additionally, Participant A10 raised concerns about the burden they sometimes face in their classes, stating, and "*The overload of information can be overwhelming for some of us."* This indicates that the abundance of online resources can overwhelm students, leading to cognitive overload. Students may have difficulty discerning relevant information from irrelevant or low-quality content. Teachers suggested that teaching information literacy skills could help students process and filter information effectively.

The issue of multitasking with digital devices emerged as a potential challenge, likely reducing the quality of learning. It is important to address this issue to minimize distractions and promote focused engagement in academic tasks.

In summary, the assessment highlighted the challenges of alignment and workload management when integrating ICT in the teaching and learning of Physics. Participants emphasized the need for alignment between online content and classroom instruction. Time management difficulties, potential distractions from non-academic online activities, information overload, and the impact of multitasking with digital devices were identified as significant challenges. Implementing strategies to address these challenges, such as providing structured guidance, teaching information literacy skills, and minimizing distractions, can enhance the effectiveness of ICT integration in Physics education.

4.4.6 Assessment challenges

In an assessment on the integration of ICT in the teaching and learning of Physics, participants raised concerns about the assessment of students, particularly regarding academic integrity. The teachers who took part in the study observed that ensuring academic integrity in online platforms was challenging.

Participant T2 expressed concern, stating, *"There are assessment challenges in ensuring academic integrity online."* This suggests that maintaining academic honesty in online assessments can be difficult.

It was observed that online assessments often lack the controlled environment of in-person exams, making it easier for students to access unauthorized materials or collaborate inappropriately. The impersonal nature of online assessments can also reduce the perceived seriousness of cheating, potentially leading to more academic dishonesty.

Participant T3 strongly agreed with Participant T2 regarding academic integrity and highlighted the difficulty of verifying the identity of the student completing the assessments. T3 stated, *"Even if someone does the online activities on behalf of our learners or even if he copies information googled from the internet, how would you know? You see the problem; you will just assume it is the learner's work."* This response underscores the risk of students outsourcing their assignments or using online services to complete exams, which makes it challenging to determine whether the work submitted is genuinely the student's own.

In summary, the assessment revealed concerns about ensuring academic integrity in online assessments within the context of the teaching and learning of Physics. Participants highlighted challenges related to preventing cheating and verifying the authenticity of students' work. The nature of online assessments, with their lack of a controlled environment and the impersonal nature of the online medium, can contribute to increased academic dishonesty. Addressing these challenges requires implementing measures to promote academic honesty, such as designing secure assessment methods and developing strategies to verify the identity of students completing online assessments.

An assessment of the integration of ICT in the teaching and learning of Physics identified possible solutions and strategies to overcome challenges and barriers associated with student engagement and motivation. It was found that integrating ICT has the potential to enhance the educational experience by improving motivation and interaction with the content.

The participants, including physics teachers, emphasized the need for a collaborative effort from educational institutions, teachers, and policymakers to effectively integrate ICT into the physics curriculum.

To address challenges related to engagement and motivation, physics teachers suggested several solutions. They recommended providing clearer guidelines and expectations for utilizing ICT tools, offering a range of resources to accommodate different learning preferences, implementing regular check-ins to monitor student progress, and providing support when needed.

Participants also highlighted the importance of enhancing interactive content by integrating ICT tools such as interactive simulations, digital tools, and diverse multimedia to cater to various learning styles. Personalized learning pathways can be created using ICT platforms, allowing adjustments based on student progress and understanding. It is crucial to provide training for teachers to effectively design and implement ICT strategies that maximize student engagement.

Improving infrastructure was identified as another measure. Educational institutions should ensure reliable internet access and provide adequate devices for students to support the integration of ICT methods.

Engaging parents and the community was seen as essential. Educators should involve parents and the community in understanding the benefits of ICT integration, seeking their support and addressing any resistance to new methods.

Implementing regular feedback mechanisms for ICT-based activities was also suggested. This includes setting up systems for ongoing feedback from students to continuously improve the learning experience with ICT.

Additionally, research and development were emphasized. The education system should encourage ongoing research into the effectiveness of different ICT approaches and adapt teaching methods accordingly.

By implementing these solutions, educators can enhance student engagement and motivation, fostering a more interactive, enjoyable, and effective learning experience in physics through the integration of ICT.

4.5 Possible Solutions Or Strategies To Overcome Challenges And Barriers Associated With The Integration Of Blended Learning Methods.

4.5.1 Possible Solutions to the Impact on Engagement and Motivation of Learners

According to the assessment on the integration of ICT in the teaching and learning of Physics, the emerging theme of increased student engagement highlights the potential of incorporating technology in enhancing the educational experience. The participants, including physics teachers, emphasized the importance of addressing barriers through a collaborative effort among educational institutions, teachers, and policymakers to ensure the effective integration of technology in the physics curriculum.

To overcome challenges associated with student engagement and motivation, educators can implement several solutions. Providing clearer guidelines and expectations for self-directed components, offering a variety of resources to cater to different learning preferences, and implementing regular check-ins to monitor student progress were suggested by school administrators and physics teachers. Additionally, they emphasized the need to enhance interactive content by continually developing and incorporating simulations, digital tools, and diverse multimedia to accommodate various learning styles. Creating personalized learning pathways for students, which can be adjusted based on their progress and understanding, using technology platforms was also recommended. Providing training for teachers to design and implement strategies that maximize student engagement in the classroom is crucial.

Improving infrastructure is another important measure. Educational institutions should ensure the availability of necessary technological resources, such as reliable internet access and adequate devices for students, to support technology-based learning methods.

Engaging parents and the community is vital. Educators should involve parents and the community in understanding the benefits of using technology in education, seeking their support, and addressing any resistance to new methods.

Implementing regular feedback mechanisms for learning activities is essential. This can be achieved by establishing systems for continuous feedback from students to enhance the learning experience. Furthermore, encouraging research and development in the field of technology integration is important. The education system should continuously explore the effectiveness of different approaches and adapt teaching methods accordingly.

By addressing these solutions, educators can enhance student engagement and motivation, leading to a more interactive, enjoyable, and effective learning experience in physics.

4.5 Possible solutions or Strategies to overcome challenges and barriers associated with the integration of ICT in teaching and learning methods.

4.5.1 Possible solutions to the impact on engagement and motivation of learners in the integration of ICT.

According to the assessment on the integration of ICT in the teaching and learning of Physics, the emerging theme of increased student engagement highlights the potential of incorporating technology in enhancing the educational experience. The participants, including physics teachers, emphasized the importance of addressing barriers through a collaborative effort among educational institutions, teachers, and policymakers to ensure the effective integration of technology in the physics curriculum.

To overcome challenges associated with student engagement and motivation, educators can implement several solutions. Providing clearer guidelines and expectations for self-directed components, offering a variety of resources to cater to different learning preferences, and implementing regular check-ins to monitor student progress were suggested by school administrators and physics teachers. Additionally, they emphasized the need to enhance interactive content by continually developing and incorporating simulations, digital tools, and diverse multimedia to accommodate various learning styles. Creating personalized learning pathways for students, which can be adjusted based on their progress and understanding, using technology platforms was also recommended. Providing training for teachers to design and implement strategies that maximize student engagement in the classroom is crucial.

Improving infrastructure is another important measure. Educational institutions should ensure the availability of necessary technological resources, such as reliable internet access and adequate devices for students, to support technology-based learning methods.

Engaging parents and the community is vital. Educators should involve parents and the community in understanding the benefits of using technology in education, seeking their support, and addressing any resistance to new methods.

Implementing regular feedback mechanisms for learning activities is essential. This can be achieved by establishing systems for continuous feedback from students to enhance the learning experience. Furthermore, encouraging research and development in the field of technology integration is important. The education system should continuously explore the effectiveness of different approaches and adapt teaching methods accordingly.

By addressing these solutions, educators can enhance student engagement and motivation, leading to a more interactive, enjoyable, and effective learning experience in physics.

4.4.2 Possible Solutions to Flexibility, Accessibility, and Connectivity Challenges in The Integration Of ICT.

The challenges of flexibility, accessibility, and connectivity in the integration of ICT in teaching and learning were identified as significant but surmountable, according to physics teachers and school administrators. By improving internet infrastructure, optimizing online resources, and ensuring equal access to technology, we can bridge the digital divide. These efforts will not only enhance the flexibility of ICT integration but also make it a truly inclusive educational model. By directly addressing these challenges, educators and policymakers can create a more equitable and effective environment for the integration of ICT, ensuring that every student has the opportunity to succeed in the digital age

Intermittent internet connectivity experienced by schools presents a major obstacle to the integration of ICT, as highlighted by Participant T3. The dependence on stable internet access is a recurring concern raised by school administrators and physics teachers. Students, such as T2 and B12, express frustration when connectivity issues disrupt their learning process, emphasizing the need for consistent online access. The observation made by Participant T1 about unequal access to technology further highlights the existence of a significant digital divide. The integration of ICT assumes that all students have personal devices, but this is not the reality for many, resulting in disparities in participation and learning outcomes.

To overcome these challenges, enhancing internet infrastructure is crucial. Teachers suggest collaborating with network service providers to improve infrastructure, particularly in remote areas. Participant T3 stated:

"*Schools should partner with internet service providers to improve infrastructure, especially in remote areas. These companies can install network boosters."* (T3)

Participant T2 recommended that school administrators advocate for government subsidies to support the installation of reliable internet connections in educational institutions. T2 stated:

"*Lobby for government subsidies to support the installation of reliable internet connections in educational institutions."* (T2)

Additionally, creating community internet hubs with robust connectivity for students to access outside school hours was suggested by T2.

In the face of poor or intermittent internet connectivity, improvising is necessary, as explained by Participant T3. They suggested:

"Poor connection is a frustration, but to overcome the internet connectivity issues, we could create offline-accessible resources and ensure that key online materials are available for download during school hours." (T3)

Developing and distributing offline-accessible learning materials to ensure continuity during connectivity outages was also proposed by Participant T4. They highlighted the importance of empowering students through equal access to digital devices, stating:

"The government, through our ministry, should provide the relevant devices and technologies or implement device lending programs to provide tablets or laptops to schools without access." (T4)

Similarly, Participant T4 emphasized the need to promote device equality among learners and suggested seeking grants and donations to fund the purchase of devices for educational use. They stated:

"As schools, we may need to seek grants and donations to fund the purchase of devices for educational use; phones and laptops to supplement school-provided devices. We want to ensure no student is left behind." (T4)

4.5.3 Possible solutions to technological challenges in the integration of ICT

The assessment revealed that technological challenges can be addressed through various means. One participant provided the following solution:

"Providing subsidized or free access to the necessary technology and internet can help." (T3)

This statement proposes a solution to a key challenge in the integration of ICT, particularly in the teaching and learning of Physics. The majority of participants in the study emphasized the importance of equitable access to technology. Subsidized or free access to technology and the internet can level the playing field, ensuring that all students, regardless of their socio-economic background, have the opportunity to participate in the integration of ICT. By removing financial barriers, more students may engage with the curriculum, potentially leading to higher course completion rates. Additionally, support for remote learning is crucial in areas where students may lack reliable access to physical classrooms, as it ensures educational continuity. Establishing partnerships with technology companies and internet service providers can offer cost-effective solutions.

A Physics teacher, T4, proposed a strategy called "Targeted support." One participant, T3, stated:

"Identifying students who most need support can ensure that resources are allocated efficiently."

While providing subsidized or free access to technology and the internet holds strong potential as a solution to the technological challenges associated with the integration of ICT, it requires careful planning and management to ensure effectiveness and sustainability. This solution addresses the immediate need for access but should be part of a broader strategy that includes training, support, and quality assurance to truly enhance the teaching and learning of Physics through the integration of ICT.

Improving infrastructure involves investing in reliable and accessible technology. Nearly all research participants expressed support for technology improvement. The need for training alongside technological advancements was emphasized by almost all participants, especially in this era of technology. Participants T3 and A13 highlighted training and support as potential solutions to technological challenges. T3 stated:

"Continuous training for educators should be offered to improve their instructional design skills and technological literacy, to enhance the quality of integrating ICT." (T3)

A1 added:

"We need intensive training as students so that we become familiar with the learning platforms and software." (A1)

These perspectives indicate that participants require more training to stay updated with technology.

Participant T4 further reinforced the views of T3 and A1 by stating:

"*Infrastructure improvement includes providing adequate devices and ensuring stable internet connectivity for both teachers and students, who should be well trained to use the technology."*

Addressing these technological challenges is crucial for the successful integration of ICT in the teaching and learning of Physics. It requires collaborative efforts from educational institutions, teachers, and policymakers to ensure equal access to the technology required for modern Physics education.

4.5.4 Possible Solutions to Alignment and Workload Management Challenges in the Integration of ICT

Aligning online materials and activities with the curriculum and learning objectives can pose challenges. One physics teacher shared their insights on potential solutions:

"Implementing a semi-structured timetable for self-paced modules, providing time management resources, and training for students would help. Establishing a structured schedule with clear deadlines would assist in managing time effectively." (T3)

The teacher highlighted the importance of encouraging students to utilize website blockers during designated study times and incorporating engaging educational technology to compete with non-academic distractions. Participant T4 also contributed valuable perspectives on workload management challenges:

"Maintaining a balance is crucial to prevent over-reliance on technology and preserve the benefits of face-to-face interaction."

Furthermore, the school administrators emphasized the need for careful consideration when integrating ICT into the curriculum. The administrator from School B shared their viewpoint: (T4)

"Curating content to provide a balanced amount of information would be helpful."

These administrators' perspectives highlighted the significance of collaborating with curriculum developers to create online resources that align with learning objectives, thus enhancing the integration of ICT in teaching and learning Physics. It is essential to ensure that the online materials and activities are thoughtfully designed to support the curriculum and enable effective learning experiences for students. Additionally, providing appropriate training and resources for both students and educators is crucial to optimize the use of ICT tools and manage workload effectively. By striking a balance between technology integration and face-to-face interaction, educators can harness the benefits of ICT while maintaining a well-rounded learning environment.

4.5.5 Possible Solutions to Infrastructure and Adaptability Challenges In The Integration of ICT

The assessment of infrastructure and adaptability challenges in the integration of ICT has identified several key areas that require attention. Adaptability refers to the need for the education system to incorporate new methods of teaching and learning. The following solutions were proposed by the research participants:

Policy development and funding:

"Clear guidelines should be developed, and funding can be secured. Comprehensive policies providing clear guidelines on technology use in education can facilitate the adoption of ICT integration. Institutions can advocate for policies that allocate funding specifically for technology infrastructure and teachers' professional development." (T3)

Professional development:

"Continuous training programs for teachers focusing on blended learning pedagogies, technological proficiency, and online student engagement strategies should be implemented. Support systems, including resources, mentorship, and a community of practice to share experiences and best practices, can also be created." (T4)

Psychological support:

"Fostering a sense of community is encouraged. Online discussion forums and collaborative projects can be developed to reduce feelings of isolation and promote a sense of belonging. Personalized support, such as counselling services and workshops, should be provided to students who feel isolated to help them cope with the psychological challenges of ICT integration." (T3)

Curriculum and instructional design:

"A blended learning curriculum should be designed, striking a balance between online and face-to-face interaction. Teachers should receive training in instructional strategies effective in a blended learning environment, such as flipped classrooms and project-based learning." (T1)

Participant T1 emphasized the importance of teacher training:

"Conducting professional development workshops for teachers on blended learning is crucial." (T1)

Technological adaptability:

"Simplifying technology use is essential. Educators should streamline the number of platforms used and ensure they are user-friendly to reduce the overwhelm of adapting to various online platforms. Regular workshops and seminars should be conducted to encourage a culture of technological adaptability among teachers and students." (T3)

Mind-set shift:

"Awareness campaigns through workshops and seminars on the benefits and methods of blended learning are essential. Change management strategies should be employed to support educators

and students in transitioning to blended learning, addressing resistance and promoting acceptance." (T4)

Comprehensively addressing these challenges, including infrastructure improvement, policy development, professional training, psychological support, and a supportive curriculum, will enable the full realization of the potential of ICT integration in physics education. It is crucial to consider the emotional well-being of students and the readiness of teachers to ensure a successful transition to this innovative educational model.

4.5.6 Possible solutions to assessment challenges in the integration of ICT

The assessment of challenges in online education, particularly regarding academic integrity, highlights two main issues: proxy test-taking and plagiarism. To address these challenges in the integration of ICT, the following potential solutions were identified:

Utilizing Proctoring Software:

"Educators can implement software that monitors students during assessments through video, audio, and activity tracking to deter cheating." (T3)

However, it is important to note that implementing such software may require a well-developed online platform for ICT integration. Privacy concerns and potential intrusiveness associated with these technological solutions must also be considered.

Integration of Turn tin for Plagiarism Detection:

"*Educators can use Turn tin to check for copied content in learners' submissions."* (T4)

While plagiarism checkers and proctoring software can be effective to some extent, they are not foolproof and can be circumvented. Therefore, additional measures are necessary.

Designing Assessments:

"The design of assessments should emphasize critical thinking and the application of knowledge, which are harder to cheat on compared to multiple-choice or direct-answer questions." (T3)

Educators should focus on creating assessments that require higher-order thinking skills, promoting originality and deep understanding of the subject matter. Workshops for learners on the importance of academic integrity and proper citation of sources can also help reinforce these principles.

The school physics (T3) emphasized the need to educate students about academic integrity:

"Educating students about the importance of academic integrity and the consequences of dishonesty." (T3)

Educators should be vigilant in fostering a culture of integrity, clearly defining what constitutes cheating, and ensuring students understand the boundaries. Enforceable policies on academic integrity should be established, with support systems in place for reporting and addressing instances of dishonesty.

Regular updates to course materials, including changing assessment questions and content, can help prevent the circulation of answers. Peer reviews can also be implemented, encouraging learners to evaluate each other's work and promoting accountability, thus reducing the likelihood of cheating.

By implementing a combination of these strategies, educational institutions can enhance the integrity of online assessments, ensuring that the work submitted reflects the learners' own efforts and understanding. It is crucial to recognize that while the integration of ICT offers flexibility and accessibility, it also presents challenges in maintaining academic integrity. Therefore, a multifaceted approach involving technology, pedagogy, and policy is essential to effectively address these challenges.

4.6 Discussion

In this section, the researcher synthesizes real-world observations with scholarly perspectives on the integration of Information and Communication Technology (ICT) in high school physics education. The project, titled "An Evaluation of the Integration of ICT in the Teaching and Learning of Physics at Ordinary Level," investigates how innovative ICT methods can be incorporated into conventional physics teaching practices. Insights gleaned from an extensive literature review have informed the structure of this discussion, serving as a beacon that illuminates the potential of ICT to transform education while also shedding light on its potential drawbacks.

The primary focus of this discussion is to explore how the integration of ICT can invigorate classrooms and cater to diverse learning preferences among students in the field of physics. By leveraging digital technologies, teachers can enhance classroom dynamics, create interactive learning experiences, and provide personalized instruction. However, the discussion acknowledges the challenges that educators and learners may encounter, such as technological deficiencies and limited access to resources.

The literature review presents a range of perspectives on these challenges. While some view them as significant obstacles, others adopt a more optimistic view, emphasizing the potential of blending new and traditional teaching methodologies. In light of these perspectives, the research aims to propose practical solutions that address the challenges identified, drawing from both literature insights and empirical findings from the study.

Guided by the research questions, the researcher delves into the merits of ICT integration, confronts the challenges, and seeks out resolutions. By comparing the collected data with academic theories, the researcher aims to assess the congruence between research findings and existing scholarly works, strengthening the validity and reliability of the study.

Through this discussion, it becomes evident that the integration of ICT in physics education holds transformative potential, capable of revolutionizing the learning experience for both teachers and students. The outcomes of this study aim to assist educators, policymakers, and academics in crafting an enhanced educational milieu for physics, leveraging the strategic implementation of ICT.

4.6.1 1 What are the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level?

4.6.1.1 Comparison of research findings on benefits with related literature.

4.6.1.1.1 Student engagement

The convergence between the literature and the current research findings on the integration of ICT in the teaching of physics is evident. Both sources emphasize the enhanced engagement and motivation that ICT integration brings to educational settings. According to Krasnova and Shurygin (2019), blended learning "encourages active participation," while Powell et al. (2015) suggest that it "creates online communities and learning practices." These perspectives align with the observed increase in student engagement in physics through the use of interactive content and digital tools in the current research.

Additionally, the research findings echo Garrison and Kanuka's (2014) emphasis on the inspiring learning environment fostered by the combination of classroom and online instruction. The personalized aspect of ICT integration, highlighted in the research, corresponds with the literature's advocacy for active participation and collaboration. Thus, the research findings not only support but also reinforce the literature's claims, providing practical evidence of the benefits of integrating ICT in promoting an engaging and motivating educational experience.

4.6.1.1.2 Flexibility, accessibility, and control

The integration of ICT in the teaching and learning of physics, as discussed in the literature and supported by research findings, offers significant benefits in educational settings. The literature emphasizes the flexibility and accessibility that ICT integration provides, allowing students to access materials at their convenience and catering to diverse learning styles and needs (Giarla, 2016; Powell et al., 2015). This notion aligns with the research findings, which highlight the flexibility of ICT integration in physics education. It enables students to have control over their learning pace and access modern materials and innovative pedagogical approaches from any location.

Furthermore, both sources agree on the importance of self-pacing. Clark and Mayer (2016) suggest that self-pacing can reduce stress and increase satisfaction, which is in line with the research findings where students having control over learning resources and pace are seen to foster a self-directed approach. This approach is associated with increased motivation and a more dynamic learning experience, as acknowledged by teachers and administrators in the research findings.

4.6.1.1.3 Collaboration and active participation in group activities foster deeper learning, critical thinking, and self-directed learning

The integration of ICT in the teaching and learning of physics, as supported by the research findings, transcends traditional pedagogy and creates an environment that promotes active learning and the practical application of physics theories. This educational shift aligns with the literature, as Lalima and Dangwal (2017) highlight its capacity for "cooperative learning across settings," and Tayebinik and Puteh (2012) recognize its integral role in instructional modalities.

Moreover, Bakeer (2018) underscores the adaptability of ICT integration to individual learning styles, which is essential for personalized education. The research findings further reveal that learners not only find enjoyment in interactive content and collaborative online discussions but also appreciate the diverse range of resources offered through ICT integration. This leads to a personalized and immersive learning experience. Additionally, the research findings indicate that this approach fosters critical thinking and problem-solving skills, empowering students to take charge of their learning journey and apply knowledge in real-world contexts.

Thus, the integration of ICT signifies a transformative shift from passive reception to an active, technology-integrated education—a true reflection of the dynamics of 21st-century learning.

4.6.2 Research Question 2 What Are the Perceived Benefits and Challenges Of Using ICT In Teaching And Learning Physics?

4.6.2.1 Comparison of Research Findings on Challenges and Barriers with Related Literature.

The research findings on the challenges of integrating ICT in physics education resonate with the issues highlighted in the related literature. As mentioned by Becirovic (2023), the lack of specialised equipment or software aligns with the researcher's observation of technical issues and unreliable internet connectivity that disrupt the continuity of learning. Francom (2020) emphasises the importance of physics simulations, virtual laboratories, and modelling software, which are crucial for an engaging learning experience but are often hindered by high costs and technical proficiency requirements. This challenge, noted by the researcher, impacts inclusivity and student engagement.

The lack of expertise among teachers in both subject matter and ICT tools, as pointed out by Kuo et al. (2014) and Benson et al. (2014), is consistent with the research findings regarding professional development gaps and the need for training in ICT-integrated pedagogies. This lack of expertise can lead to student confusion and hinder learning, which the research identifies as a significant barrier to student motivation and engagement.

Hamutoglu (2021) emphasizes the need for adequate technical support, corresponding to the challenges identified by the researcher in maintaining student focus and providing clear instructions and scaffolding. Bai and Lo (2018) discuss the necessity of intentional planning for effective collaboration and communication, echoing the researcher's suggestion for more collaborative tools and strategies to address the absence of hands-on experiments and peer interaction in online settings.

Furthermore, Amandu et al. (2013) mention the inadequate training and familiarity with digital tools among teachers, which is a concern shared by the research findings, particularly in terms of equitable technology access and clear guidelines. The resistance to change among educators, favouring traditional methods over new ICT-integrated approaches, is a cultural challenge identified by both the research findings and the literature as an obstacle to successful implementation.

Therefore, the literature provides a solid foundation that supports the research findings. The challenges of integrating ICT in physics education are multifaceted, encompassing technical, instructional, and cultural barriers. Addressing these challenges necessitates a collective effort to provide equitable access to technology, offer professional development for educators, and engage in planning to create a supportive and effective ICT-integrated learning environment. By recognizing and addressing these issues, educators can foster a more inclusive and engaging learning experience for students in physics education.

4.6.3. Research Question: What Strategies Can Be Recommended For Effective Integration Of ICT In The Teaching And Learning Of Physics At The Ordinary Level?

4.6.3.1 Comparison of Research Findings on Possible Solutions to Related Literature.

The integration of ICT in physics education at the ordinary level presents a unique set of challenges and opportunities. The findings of this research provide a comprehensive set of solutions that align well with the related literature, indicating a consensus on the strategies needed to overcome these barriers.

Enhancing interactive content: Both the research findings of this study and Alvarez (2020) emphasise the importance of interactive content. Alvarez suggests investing in robust infrastructure and training for educators and students, which supports the researcher's recommendation to develop interactive simulations and multimedia content. This alignment indicates a shared understanding of the need for engaging and diverse educational materials in ICT-integrated learning environments.

Personalized learning pathways: The findings on personalized learning pathways are echoed by Becirovic (2023), who advocates for clear learning objectives aligned with assessment methods. This suggests a literature-backed approach to creating tailored educational experiences that cater to individual student needs and progress.

Infrastructure improvement: The necessity of reliable internet access and adequate devices, as highlighted in this research, is reinforced by the literature. Alvarez (2020) calls for robust infrastructure, which directly supports the researcher's strategy for infrastructure improvement. This agreement underscores the critical role of technology in facilitating effective ICT integration.

Community engagement: The findings on community engagement find resonance in the literature's emphasis on collaboration and interdisciplinary cooperation, as mentioned by Adams et al. (2017). The literature suggests that involving all stakeholders, including parents and the community, is essential for the successful adoption of ICT-integrated teaching and learning methods.

Regular feedback mechanisms: The implementation of regular feedback systems in the findings is not directly addressed in the literature. However, the call for detailed instructions and active engagement through discussion forums by Benson et al. (2014) implies a need for ongoing communication and assessment, which can be facilitated by feedback mechanisms.

Flexibility, accessibility, and connectivity: The literature supports the research strategies for enhancing internet infrastructure and ensuring equal access to digital devices. The collaboration with network service providers and lobbying for government subsidies, as suggested by the participants of this study, is a practical approach that aligns with the literature's call for investment in technology and support systems.

BYOD policies: While the literature does not specifically mention BYOD policies, the emphasis on user-friendly platforms and tools suggests a literature-supported move towards flexible and accessible technology use, which BYOD policies can facilitate.

Assessment challenges: The possible solutions to assessment challenges, such as implementing proctoring software and designing critical thinking assessments, align with the literature's focus on academic integrity and proper citation practices. This alignment indicates a shared concern for maintaining the authenticity of learners' work.

In summary, the literature largely agrees with the research findings on the possible solutions to overcome challenges and barriers, providing a robust framework for addressing the challenges associated with integrating ICT in physics education. The consensus points to a multifaceted approach involving technological investment, pedagogical innovation, community involvement, and continuous improvement through feedback. By implementing these strategies, educators can create a more inclusive, engaging, and effective learning environment that prepares students for success in the digital age. The discussion reflects a harmonious blend of the research findings with the related literature, reinforcing the potential of ICT integration to transform physics education at the ordinary level.

CHAPTER 5: SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction:

This chapter serves as the culmination of the study, synthesizing the key themes and discussions that have shaped the investigation into the integration of Information and Communication Technology (ICT) in the teaching and learning of physics. It revisits the fundamental research questions that guided this study, outlining the paths taken to address them and shed light on the topic. The chapter distils the essence of the research discoveries, emphasizing the valuable contributions made by this study.

Beyond theoretical insights, this chapter provides practical guidance for policymakers, educators, and communities, advocating for the seamless integration of ICT strategies within ordinary-level physics pedagogy. By drawing from the research findings and insights from the literature, this chapter compares and aligns the study's outcomes with existing scholarly works. It highlights the areas of agreement and identifies any novel contributions or perspectives that emerged from this study.

The discussion extends beyond a mere review of the literature, aiming to provide a comprehensive analysis and synthesis of the findings concerning the existing body of knowledge. By comparing the research outcomes with the literature, this chapter establishes the validity and relevance of the study, bolstering its significance within the broader academic context.

Furthermore, this chapter looks ahead and sets the stage for future inquiries into the integration of ICT in the teaching and learning of physics. It identifies potential avenues for further exploration, suggesting areas that require additional investigation, and offers a vision for the future of academic exploration in this field. By highlighting the gaps and limitations of the current study, it paves the way for subsequent research to build upon and expand the existing knowledge base.

5.2 Summary of the Study

This research focused on assessing the integration of ICT methods in the teaching and learning of physics at the ordinary level in two selected secondary schools in the Guruve district. The motivation for this study arose from the recognition of the increasing emphasis on the integration of ICT in academic discourse, coupled with the challenges encountered during its implementation. Consequently, the researcher embarked on an exploration of the perspectives held by physics educators, and ordinary-level physics learners regarding the integration of ICT.

The constructivist approach was deliberately chosen for this study to facilitate an understanding of the subjective experiences of the participants, allowing for the co-construction of knowledge through their unique perspectives. This approach aligns seamlessly with the study's aim to unravel the intricacies of ICT integration, as it emphasizes the importance of context and the active roles of learners and educators in shaping their educational journey.

Throughout the study, data was collected through various methods, such as interviews, observations, and questionnaires, to gather insights into the experiences, perceptions, and challenges associated with the integration of ICT in physics education. The findings of the study provided valuable insights into the benefits, challenges, and potential solutions related to the integration of ICT in the teaching and learning of physics at the ordinary level.

In comparing the research findings with the existing literature, several points of convergence and divergence emerged. The literature review served as a foundation for understanding the theoretical underpinnings and existing frameworks related to ICT integration in education. By comparing the findings with the literature, the study validated and extended existing knowledge, identifying areas where the findings aligned with previous research and areas where new perspectives or insights emerged.

The study's findings highlighted the potential of ICT integration in physics education, such as enhancing student engagement, promoting active learning, and facilitating personalized instruction. However, challenges were also identified, including limited access to technology, inadequate teacher training, and resistance to change. The study proposed practical solutions to address these challenges, drawing from both the literature and the empirical findings.

The study on the integration of ICT in the teaching and learning of physics was structured into five comprehensive chapters:

Chapter 1: Introduction and Framework

This chapter provided an introduction to the study, outlining the background, objectives, and research question driving the inquiry. It also clarified the scope, significance, and foundational assumptions of the study, while defining key terminologies related to the integration of ICT in physics education.

Chapter 2: Review of Related Literature

In this chapter, a comprehensive review of existing literature was presented, aligning the literature review with the research questions to establish a strong theoretical foundation for the study. The literature review synthesized theoretical insights and frameworks related to the integration of ICT in the teaching and learning of physics.

Chapter 3: Methodology

This chapter detailed the qualitative multi-case study design employed in the research. It described the selection process for the participating schools, outlined the data collection methods (interviews, lesson observations, questionnaires), and explained the thematic analysis approach used. The methodology chapter emphasized the qualitative nature of the research and addressed the gaps the study aimed to address.

Chapter 4: Data Presentation, Analysis, and Discussion

The focus of this chapter was on presenting the collected data, analysing it, and engaging in a critical discussion. The findings were presented, and a thematic synthesis was conducted, organically emerging from the research questions. Data narratives were recorded, and insights were deduced from these narratives. The chapter facilitated a comparison of the findings with existing literature, highlighting areas of agreement and identifying any novel contributions or perspectives that emerged.

Chapter 5: Summary of the Study and Conclusion

This final chapter provided a summary of the entire study, bringing together the key themes, discussions, and discoveries. It highlighted the contributions made by the study and offered pragmatic guidance for policymakers, educators, and communities interested in the integration of ICT in the teaching and learning of physics. The chapter also laid the groundwork for future research, identifying potential areas for further exploration and envisioning the future horizons of academic inquiry in this field.

5.3.1 Conclusions on research question 1

Current Practices in Zimbabwe:

a. Blended Learning Approaches: The study revealed that blended learning approaches, combining traditional face-to-face instruction with the use of ICT tools and resources, are being implemented in Zimbabwean schools for teaching physics. These approaches involve the integration of online resources, simulations, and digital tools to enhance student engagement and understanding of physics concepts.

b. Availability of Educational Software: The study found that educational software and digital resources specific to physics education are being utilized in Zimbabwean classrooms. These resources provide interactive content, simulations, and virtual experiments, allowing students to explore and apply physics principles in a virtual environment.

c Teacher-Driven Integration: The study highlighted the role of motivated and innovative teachers in driving the integration of ICT in physics education. Teachers were found to actively seek out and incorporate ICT tools and resources into their lesson plans, adapting them to suit the local context and addressing the specific needs of their students.

Challenges in Zimbabwe:

a. Limited Access to Technology: The study identified limited access to technology as a significant challenge in Zimbabwe. Some schools lacked the necessary infrastructure, including computers and internet connectivity, which hindered the effective integration of ICT in physics education.

b. Inadequate Teacher Training: The study revealed that teachers faced challenges in effectively utilizing ICT tools and resources due to a lack of adequate training. Limited professional development opportunities and support for teachers in integrating ICT into their pedagogy were identified as barriers to successful implementation.

c. Infrastructure and Maintenance: The study highlighted issues related to infrastructure and maintenance of ICT resources. Schools faced challenges in maintaining and repairing technological equipment, leading to disruptions in the integration of ICT in physics education.

5.3.2 Conclusions on research question 2

Perceived Benefits of Using ICT in Teaching and Learning Physics:

Enhanced Engagement and Interest: The study found that the use of ICT tools and resources in physics education increased student engagement and generated interest in the subject. Interactive simulations, multimedia presentations, and online resources captured students' attention and made learning physics more engaging and enjoyable.

Improved Understanding and Conceptualization: The integration of ICT facilitated a deeper understanding and conceptualization of physics concepts. The study revealed that interactive simulations, virtual experiments, and digital visualizations helped students visualize abstract concepts, grasp complex phenomena, and apply theoretical knowledge in practical contexts.

Access to a Wide Range of Resources: The study highlighted that integrating ICT in physics education provided students with access to a wide range of resources beyond traditional textbooks. Online platforms, educational websites, and digital libraries offered a wealth of supplementary materials, including videos, articles, and practice exercises, enabling students to explore physics in depth.

Perceived Challenges of Using ICT in Teaching and Learning Physics:

Limited Access to Technology: The study identified limited access to technology as a significant challenge in Zimbabwe. Some schools lacked the necessary infrastructure, including computers and internet connectivity, which restricted students' access to ICT tools and resources.

Teacher Training and Support: Insufficient teacher training and support for effectively integrating ICT in physics education were noted as challenges. The study found that some teachers lacked the necessary knowledge and skills to utilize ICT tools optimally, limiting their ability to leverage technology for improved teaching and learning outcomes.

Infrastructure Maintenance and Sustainability: The study highlighted challenges related to infrastructure maintenance and sustainability. Schools encountered difficulties in maintaining and repairing technological equipment, which hindered the seamless integration of ICT in physics education.

5.3.3 Conclusions on research question 3

What strategies can be recommended for effective ICT integration in the teaching and learning of physics at the ordinary level?

Infrastructure Development:

a. Improve Access to Technology: Efforts should be made to ensure schools have access to adequate ICT infrastructure, including computers, internet connectivity, and necessary software and hardware. This can involve government initiatives, partnerships with organizations, and fundraising efforts to bridge the digital divide.

b. Establish Maintenance and Support Systems: Establishing systems for regular maintenance and technical support is crucial to ensure the smooth functioning of ICT resources. Schools should have trained personnel or partnerships with technical experts who can address any technical issues promptly.

Teacher Training and Professional Development:

a. Provide Comprehensive Training: Teachers should receive comprehensive training on integrating ICT tools and resources effectively into physics instruction. Training programs should focus on enhancing their technological skills, pedagogical knowledge, and ability to design and implement technology-enhanced lessons.

b. Ongoing Professional Development: Continuous professional development opportunities should be provided to teachers to keep them updated on emerging technologies and innovative teaching methods. These can include workshops, webinars, and collaborative learning communities where teachers can share experiences and best practices.

Curriculum Design and Resource Development:

a. Align ICT Integration with Curriculum: The integration of ICT should be aligned with the physics curriculum, ensuring that technology is used to enhance and supplement the existing content and learning objectives. ICT tools and resources should be selected based on their relevance and alignment with the curriculum goals.

b. Develop and Curate Quality Resources: Develop and curate a repository of high-quality digital resources, including simulations, virtual experiments, interactive modules, and multimedia presentations. These resources should be easily accessible to both teachers and students, providing them with engaging and relevant materials to support their learning.

Collaboration and Partnerships:

a Foster Collaboration among Stakeholders: Encourage collaboration among teachers, school administrators, policymakers, and technology experts to develop a shared vision and strategy for ICT integration in physics education. Regular meetings, workshops, and forums should be organized to facilitate knowledge-sharing and collaboration.

b. Establish Partnerships with Technology Providers: Collaborate with technology providers, educational institutions, and organizations to access affordable and up-to-date ICT tools, software, and resources. Partnerships can also provide opportunities for training, technical support, and resource sharing.

5.4 Contributions of the Study

Enhanced student engagement: The study contributes to the understanding that the integration of ICT in physics education enhances student engagement. By utilizing ICT tools and resources, such as simulations, virtual experiments, and online platforms, students become actively involved in the learning process, leading to increased engagement and motivation.

Flexibility and accessibility: The findings of the study shed light on the flexibility and accessibility offered by the integration of ICT in physics education. ICT integration allows for personalized and adaptable learning experiences, catering to diverse learning styles and preferences. This promotes inclusivity and ensures that students with varying schedules and needs can access educational materials and resources.

Collaboration and critical thinking: The research highlights the potential of ICT integration to foster collaboration, active participation in group activities, and the development of critical thinking skills. Through online discussions, collaborative projects, and problem-solving activities facilitated by ICT, students are encouraged to think critically, analyze information, and apply physics concepts in real-world contexts.

Identification of challenges and barriers: The study identifies key challenges and barriers to the effective integration of ICT in physics education. It highlights issues such as limited access to technology, inadequate teacher training, and infrastructure maintenance. By acknowledging these challenges, the study contributes to raising awareness and paving the way for addressing these obstacles effectively.

Practical implications for policy and practice: The study provides practical recommendations for policymakers and educators to address the challenges identified in ICT integration. These recommendations may include initiatives to improve technology infrastructure in schools, enhance teacher training programs, and promote a cultural shift towards embracing ICT in physics education.

Foundation for future research: The conclusions drawn from this study lay the foundation for future research on the integration of ICT in physics education. Further studies can delve into specific aspects such as the effectiveness of different ICT tools, the impact on student performance, and the long-term effects of ICT integration. This contributes to ongoing advancements in effective teaching and learning practices in physics education.

5.5 Recommendations to the Ministry of Primary and Secondary Education.

Invest in Infrastructure: Allocate sufficient funds to improve and maintain the technological infrastructure necessary for effective ICT integration in physics education. This includes providing schools with reliable internet access, modern computers, interactive whiteboards, and other necessary hardware and software.

Develop Policies: Create policies that promote and support the integration of ICT in physics education. These policies can include guidelines for the use of ICT tools and resources, strategies for infrastructure development, and initiatives such as BYOD (Bring Your Own Device) programs to encourage students to bring their own devices to enhance their learning experiences.

Provide Training: Offer comprehensive professional development programs for physics teachers to enhance their technological skills and pedagogical knowledge related to ICT integration. Training should focus on familiarizing teachers with various ICT tools, software, and online resources, as well as guiding effective integration strategies specific to physics education.

Encourage Innovation: Support and foster the development of interactive simulations, multimedia content, and other innovative digital resources that make physics education more engaging and interactive. Encouraging teachers, educational technology experts, and multimedia developers to collaborate can lead to the creation of high-quality educational materials that align with the physics curriculum.

Establish Monitoring and Evaluation Mechanisms: Implement mechanisms to monitor and evaluate the effectiveness of ICT integration in physics education. This can involve conducting regular assessments, collecting feedback from teachers and students, and analysing data to identify areas of improvement and make informed decisions regarding future ICT integration initiatives.

Foster Collaboration and Sharing: Encourage collaboration and knowledge sharing among schools, teachers, and educational institutions. Facilitate platforms and networks where teachers can share best practices, lesson plans, and experiences related to the integration of ICT in physics education. This can help create a supportive community of practice and enrich the learning experiences of both teachers and students.

By implementing these recommendations, the Ministry of Primary and Secondary Education can create an enabling environment that supports the effective integration of ICT in the teaching and learning of physics, ultimately enhancing students' engagement, understanding, and achievement in the subject.

5.5.2 Recommendations to the Teachers

Embrace ICT Integration: Embrace the integration of ICT in your teaching practices to enhance student engagement and cater to diverse learning needs. Utilize ICT tools, such as simulations, virtual experiments, online resources, and educational software, to create interactive and immersive learning experiences for your students.

Seek Professional Development: Actively seek professional development opportunities to improve your technical proficiency and pedagogical skills related to the integration of ICT in physics education. Attend workshops, webinars, and training programs that focus on effective integration strategies, innovative teaching methods, and the use of specific ICT tools and resources.

Foster Collaboration: Encourage collaboration among your students through group activities, collaborative projects, and online discussions. By fostering collaboration, you can promote critical thinking, problem-solving skills, and the practical application of physics theories. Use collaborative tools and platforms to facilitate communication and teamwork among students.

Utilize Feedback: Implement regular feedback mechanisms to gather input from your students about their experiences with ICT integration. Use this feedback to adjust your teaching methods, identify areas for improvement, and address student needs effectively. Reflect on the feedback received and make necessary modifications to enhance the learning experience.

Provide Feedback: Actively participate in feedback systems provided by educational institutions or technology providers. Share your experiences, challenges, and successes related to the integration of ICT in physics education. By providing feedback, you can contribute to the improvement of ICT tools, resources, and support systems, helping educators refine their teaching strategies and better support learners.

Stay Updated: Keep yourself updated with the latest advancements in ICT tools, software, and resources relevant to physics education. Regularly explore new technologies, educational platforms, and online resources that can enrich your teaching and enhance student learning experiences. Engage in continuous learning to stay informed about emerging trends and best practices in ICT integration.

5.5.3 Recommendations to the Physics Learners

Engage Actively: Take an active role in your learning by utilizing the interactive content and digital tools available to you. Engage with online simulations, virtual experiments, interactive videos, and other ICT resources to enhance your understanding and make your learning experience more motivating and enjoyable.

Self-Directed Learning: Take advantage of the flexibility offered by ICT integration to control your learning pace and follow personalized learning pathways. Use online platforms and resources to access additional materials, practice exercises, and supplementary content that align with your interests and learning needs.

Collaborate: Actively participate in group activities and collaborative projects facilitated by ICT integration. Engaging in discussions, sharing ideas, and working together with your peers can enhance your understanding of physics concepts and develop your critical thinking skills. Collaborative learning opportunities can provide different perspectives and deepen your comprehension of challenging topics.

Seek Support: Don't hesitate to reach out to your teachers and peers for help when facing technical issues or gaps in understanding. Seek clarification, ask questions, and engage in discussions to overcome challenges and ensure a smooth learning experience. Take advantage of online communication tools and platforms to connect with your peers and teachers outside of the classroom.

Practice Digital Citizenship: Be responsible and respectful when using ICT tools and resources. Adhere to ethical guidelines, respect intellectual property rights, and engage in online discussions with courtesy and professionalism. Develop good digital citizenship habits that promote a safe and inclusive online learning environment.

Reflect and Provide Feedback: Reflect on your own learning experiences with ICT integration and provide feedback to your teachers. Share your thoughts, suggestions, and insights on how the integration of ICT has impacted your learning. Your feedback can help educators refine their approaches and enhance the teaching and learning of physics through ICT integration.

5.5.3 Recommendations to the Community

Support Education: Get involved in the educational process by providing resources and support for the integration of ICT in physics education. This can include donating computers, software, or other technological resources to schools, offering mentorship programs for students interested in ICT, or volunteering your expertise to assist teachers in implementing ICT tools effectively.

Promote Accessibility: Work collaboratively with network service providers, educational institutions, and policymakers to enhance internet infrastructure in the community. Advocate for equal access to technology and reliable internet connectivity, particularly in underserved areas.

By promoting accessibility, you help ensure that all learners have equal opportunities to benefit from ICT integration in physics education.

Encourage Lifelong Learning: Advocate for the importance of continuous learning and the adoption of new educational methods, including ICT integration in physics education. Encourage community members to engage in lifelong learning opportunities, such as online courses, webinars, or workshops that focus on ICT tools and their application in teaching physics. Promote the idea that learning is a lifelong journey and that embracing technology is essential in the modern world.

Foster Collaboration: Encourage collaboration and partnerships between educational institutions, community organizations, and local businesses to support the integration of ICT in physics education. Foster dialogue and cooperation to identify shared goals and develop initiatives that enhance the teaching and learning of physics through ICT integration. By working together, the community can create a supportive ecosystem that benefits both learners and educators.

By implementing these recommendations, the community can play a significant role in supporting the integration of ICT in the teaching and learning of physics. Through their collective efforts, community members can contribute to creating an inclusive and supportive environment that empowers students, prepares them for the digital age, and enhances their understanding and appreciation of physics.

5.6 Suggestions for Future Research

Building on the convergence between literature and current findings, future research should explore the longitudinal impact of integrating ICT on student engagement in physics education. Studies could investigate how sustained use of interactive content and digital tools affects motivation and learning outcomes over time. Additionally, research could examine the personalization of ICT-integrated learning environments, assessing their ability to cater to diverse learning styles and individual needs in various educational settings.

Given the benefits of flexibility, accessibility, and control offered by ICT, further studies are warranted to understand the optimal balance between online and in-person components that maximize learning efficiency. Research could also focus on the psychological aspects of self-pacing facilitated by ICT, such as its effects on stress levels and overall student well-being.

Collaboration and active participation are crucial for deeper learning and critical thinking. Future research should therefore investigate the design and implementation of collaborative activities within ICT-integrated learning frameworks, assessing their effectiveness in fostering a self-directed learning approach. Studies could also evaluate the role of technology in supporting cooperative learning across different settings and its adaptability to individual learning styles.

Addressing the challenges and barriers identified, future research should assess the technical and infrastructural needs of ICT integration in physics education. This includes evaluating the availability of specialized equipment, software, and resources needed for effective ICT integration. Strategies to overcome technical issues, such as unreliable internet access and high costs associated with advanced simulations and virtual laboratories, should be explored.

The professional development of educators is another critical area for future research. Studies should examine the effectiveness of training programs in preparing educators for ICT integration in physics education. This includes assessing their impact on teaching practices and pedagogical strategies. Additionally, research could explore the integration of technical support within educational institutions to provide ongoing assistance and clear instructions for educators.

Finally, future research should consider the cultural aspects of adopting ICT integration in physics education. It is important to identify ways to overcome resistance among educators and promote a shift towards more innovative teaching approaches. Exploring the cultural factors that influence the acceptance and adoption of ICT integration and developing strategies to foster a positive and supportive environment for change will contribute to the successful integration of ICT in physics education.

By addressing these multifaceted research areas, scholars can contribute to the development of effective ICT integration strategies in physics education, overcome challenges, and create a more inclusive and engaging learning environment that prepares students for success in the digital age.

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APPENDIX 1 Student Questionnaire

Current Practices and Challenges in ICT Integration:

Section 1: Demographic Information

1. Gender:

a) Male b) Female

2. Grade:

a) 2024 b) 2023

3. School:

a) [School A] b) [School B]

Section 2: Questionnaires

4. How frequently do you use ICT in your physics classes?

a) Never b) Rarely c) Occasionally d) Frequently e) Always

5. Which ICT tools or technologies have you used in your physics classes? (Select all that apply)

a) Interactive whiteboard

b) Computer simulations

c) Online videos or tutorials

d) Other (please specify): ______________

6. How would you rate your level of ICT skills for learning physics?

a) Novice b) Beginner c) Intermediate d) Advanced e) Expert

7. Please indicate the ICT tools used in your physics classes (check all that apply):

a) Interactive simulations

b) Online research resources

c) Presentation software (e.g., PowerPoint)

d) Other (please specify): _____________

8. Do you have access to ICT tools and the internet for your Physics learning outside class?

a) Yes b) No

Questionnaire for Students: What are the perceived benefits and challenges of using ICT in teaching and learning physics?

9. ICT has helped improve my understanding of Physics concepts.

a) Strongly disagree b) Disagree c) Neutral d) Agree Strongly e) agree

10. The use of ICT makes Physics class more interesting.

a) Strongly disagree b) Disagree c) Neutral d) Agree Strongly e) agree

11. The use of ICT has motivated me to learn Physics better.

a) Strongly disagree b) Disagree c) Neutral d) Agree Strongly e) agree

12. How has using ICT in physics affected your interest and engagement in learning?

13. Has the use of ICT motivated you to learn Physics better? Explain.

14. In your opinion, what are the benefits of using ICT in the teaching and learning of physics?

15 What challenges do you face when using ICT in your physics classes? How do these challenges affect your learning experience?

16. Have you observed any differences in your understanding and engagement with physics concepts when ICT is used compared to traditional teaching methods? Please explain.

17. Do you find ICT-enhanced lessons more engaging and relevant?

Questionnaires for Students What strategies can be recommended for effective ICT integration in the teaching and learning of physics at the ordinary level?

- What other ICT tools would help improve your Physics learning?
- How can teachers better integrate ICT in their Physics teaching?
- Based on your experience, what strategies do you recommend for the effective integration of ICT in the teaching and learning of physics?
- What type of ICT activities do you find most useful for understanding physics concepts?

APPENDIX 2

Interviews Schedule

What are the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level?

1. Can you describe your experience with integrating ICT in the teaching of physics?
2. What ICT tools or technologies do you use in your physics classes?
3. What strategies or recommendations do you have for effective ICT integration in the teaching and learning of physics?
4. In what ways has ICT been used in your physics classes? Can you provide examples?
5. How do you feel the use of ICT affects your learning and engagement with physics? Please explain.
6. What advice would you give your physics teacher about using ICT?

Interviews with Teachers: What are the perceived benefits and challenges of using ICT in teaching and learning physics?

7. In your opinion what benefits have you noticed from using ICT with your students? Provide examples.
8. What challenges do you face when integrating ICT into the teaching of physics?
9. What factors do you think hinder the effective use of ICT in teaching physics?
10. What ICT activities or resources have been most helpful for understanding concepts? Why?

<u>Interviews with Teachers</u>: What strategies can be recommended for effective ICT integration in the teaching and learning of physics at the ordinary level?

1. What recommendations would you make to enhance ICT integration in physics? What recommendations would you make for effective ICT integration in physics lessons?
2. How do you address the challenges faced during ICT integration? Are there any strategies or solutions you have found effective?
3. Based on your experiences, what strategies would you recommend for effective ICT integration in the teaching and learning of physics at the ordinary level?
4. Do you have any suggestions or recommendations for improving the integration of ICT in physics classes?
5. What support do you need to better integrate ICT?
6. What strategies would you recommend for other teachers to effectively integrate ICT?

APPENDIX 3

Classroom Observation

What are the current practices and challenges in integrating ICT in the teaching of physics at the ordinary level?

The observations will involve visiting Physics classrooms to observe the actual implementation of ICT tools in teaching.

The observations will focus on the types of ICT tools used, the level of student engagement during ICT-based activities, and the overall effectiveness of ICT integration in supporting students' learning of Physics.

Observers will document their observations using a predefined checklist that captures key aspects such as the integration of ICT tools, the level of student participation, and the effectiveness of ICT in enhancing students' understanding of Physics concepts.

By employing these research instruments, we will gather valuable data to assess the current state of ICT integration in the teaching and learning of Physics. This will enable us to identify challenges, opportunities, and potential strategies for effective ICT integration in Physics education.

Classroom Observation Guide

Lesson date: ___________ Lesson topic: ______________ Teacher: ________________

ICT Used:

☐ Interactive whiteboard ☐Laptops ☐Tablets ☐Other: ___________

Teacher ICT use:

☐ Presentation ☐ Demonstration ☐ Student activities ☐ other: _______

Student Engagement:

☐ High ☐ Medium ☐ Low

Challenges Noted:

☐ Technical issues ☐ Lack of skills ☐ unclear objectives ☐ other: ______

Classroom Observation Checklist

1. Frequency of ICT use in the physics class:

a) Never

b) Rarely

c) Occasionally

d) Frequently

e) Always

Teacher guidance and support during ICT-based activities:

a) Insufficient

b) Adequate

c) Excellent

Challenges or issues observed during ICT integration: (Open-ended response)

- Instructional strategies employed by the teacher.
- Student engagement and participation during ICT integration.
- Challenges encountered during the implementation of ICT.
- Strategies implemented by the teacher to address challenges and enhance ICT integration.
- Use of ICT tools to support conceptual understanding and problem-solving in physics.
- Collaboration and interaction among students during ICT integration.
- Teacher's facilitation of ICT-based activities and discussions.
- Student reactions and responses to ICT-based instruction.
- Are there any other noteworthy observations related to ICT integration?

Classroom Observations:

- Identify best practices and areas for improvement.
- Observe how teachers adapt their teaching methods based on student responses.

APPENDIX 4 **University Memo**

SAMED

P Bag 1020
BINDURA
ZIMBABWE

Tel: 0271 - 7531 ext 1038
Fax: 263 - 71 - 7616

BINDURA UNIVERSITY OF SCIENCE EDUCATION

Date: ....

TO WHOM IT MAY CONCERN

NAME: Murombedzi T. REGISTRATION NUMBER: B1747820

PROGRAMME: HBScEd PH PART: 2:2

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

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

An assessment on the integration of ICT in the teaching and learning of Physics.

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

Your co-operation and assistance is greatly appreciated.

Thank you

BINDURA UNIVERSITY OF SCIENCE EDUCATION
DEPARTMENT OF EDUCATIONAL FOUNDATIONS
9 APR 2024
P. BAG 1020
BINDURA

Z Ndemo (Dr.)
CHAIRPERSON - SAMED