An assessment into the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Ordinary level Biology in selected schools in Mhondoro-Ngezi District, Mashonaland West Province.

BY

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RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE HONOURS BACHELOR OF SCIENCE EDUCATION BIOLOGY (BScEdHBz)

2025

Approval Form

The undersigned certify that they have read and recommend to the Bindura University of Science Education for acceptance of a dissertation entitled "An assessment into the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Biology at Wanganui High school in Mhondoro-Ngezi District, Mashonaland West Province."

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Year Granted: 2025

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I declare that this dissertation has been a result of my original efforts and investigations and such work has not been presented elsewhere for the purpose of degree assessment. Additional sources of information have been acknowledged by means of references.

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Dedication

This research is dedicated to my beloved wife, whose unwavering support and endless encouragement has been my anchor through every challenge. To my son, whose curiosity and joy inspire me to pursue knowledge and make a difference; to my mother, whose wisdom and strength have guided me throughout my life. To my family at large, whose love and belief in me have made this work possible.

Your presence in my life is the foundation of this endeavor, and for that, I am forever grateful.

Acknowledgements

My deepest gratitude goes to my tutor, Mr. Muzamba, whose expertise, patience and mentorship guided me through every stage of this research. His encouragement kept me focused and inspired.

I owe an immense debt to my family: my wife, for her boundless love and encouragement; my son, whose curiosity inspires me daily and my mother, whose wisdom has always been my guide. Your unwavering support carried me through this journey.

To everyone who contributed, directly or indirectly, thank you for being part of this milestone.

Abstract

This study was conducted to find out how Biology teachers integrate Information Communication Technology (ICT) in teaching and learning activities. The plan for carrying out this study was motivated by various policies such as under the Ministry of Primary and Secondary Education's ICT Policy (2019–2023) and the National ICT Policy (2022–2027), which align with Vision 2030's goal of fostering a knowledge-based economy and promote digital literacy to prepare students for a technology-driven world. However, teaching and learning of Biology requires much use of technology, the information regarding to teachers if they are using ICT in teaching and learning Biology is inadequate. This qualitative research study, therefore, explored how teachers integrate ICT in teaching and learning of Biology in selected secondary schools in Mhondoro-Ngezi district in Mashonaland West Province. Data were collected using interviews, classroom observations and documentary analysis. The findings from the study showed that teachers were willing to integrate ICT in teaching and learning Biology if there were adequate facilities, reliable infrastructures, and well trained in ICT integration. Teachers and students appreciated the importance of applying ICT in teaching and learning Biology. However, in order to benefit with ICT in teaching and learning Biology, they needed support so as to overcome the barriers which hinders ICT integration in Biology. Again, integration of ICT in teaching and learning Biology seemed to be critical issue to many teachers. This is due to the system of ICT training they have acquired in teachers' colleges. Colleges train

teachers ICT basics but not ICT as teaching and learning tool. As a result, teachers face challenges of applying it in classroom practices. This study recommended that further researches to be conducted in future for schools which have different characteristics to see if they have similar needs and challenges for ICT integration.

Contents

CHAPTER 1

1.0 Introduction to the study

This research study was aiming to assess the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Ordinary level Biology at selected schools in Mhondoro-Ngezi District, Mashonaland West Province. This chapter focused on the background to the study, statement of the problem, research questions, research objectives, hypothesis, justification, delimitation and limitations on the benefits of integrating ICT in enhancing the teaching and learning of Biology at the selected schools, definition of terms and a summary of this chapter. A case study of selected schools in Mhondoro-Ngezi District of Mashonaland West Province.

1.2 Background of the study

The integration of Information and Communication Technology (ICT) into education has become a global priority, transforming teaching and learning by providing innovative tools to enhance engagement, visualization, and access to resources (UNESCO, 2018). In Zimbabwe, the government has prioritized ICT in education through policies such as the Ministry of Primary and Secondary Education's ICT Policy (2019–2023) and the National ICT Policy (2022–2027), which align with Vision 2030's goal of creating a knowledge-based economy (Government of Zimbabwe, 2022). These policies aim to equip schools with digital infrastructure, train teachers in ICT skills, and promote digital literacy to prepare students for a technology-driven world (Ministry of Primary and Secondary Education, 2019). However, implementation in rural areas, such as in Mhondoro Ngezi District, is hindered by challenges including limited electricity, poor internet connectivity (with national internet penetration at 62.6% and lower in rural areas), and inadequate resources (World Bank, 2023; Chitanana, 2020).

Biology education, which involves complex concepts such as genetics, ecology, and human physiology, benefits significantly from interactive and practical approaches (Mukama & Andersson, 2019). Traditional teaching methods in Zimbabwe, often reliant on rote learning and limited by high textbook-to-student ratios of up to 1:52 in some schools, struggle to foster deep understanding (Nziramasanga, 1999). ICT tools, including virtual simulations, multimedia content, and e-learning platforms, can enhance visualization and experimentation, making

abstract concepts more accessible, especially in resource-scarce settings where physical laboratories are limited (Tshuma and Ndemo, 2021). For example, digital simulations can replicate laboratory experiments, improving student engagement and conceptual understanding (Phiri & Mlotshwa, 2022).

Mhondoro Ngezi District, a rural area in Zimbabwe's Mashonaland West Province, faces significant barriers to ICT integration, including unreliable electricity and limited broadband access (Chitanana, 2020). Despite initiatives like the Presidential e-Learning and Computerisation Programmes, which have provided computers to some schools since 2005 (Government of Zimbabwe, 2022), the impact of ICT on teaching and learning outcomes in subjects like biology remains underexplored. Global studies indicate that ICT integration can improve student performance, critical thinking, and engagement (UNESCO, 2018; Mukama and Andersson, 2019), but context-specific evidence from rural Zimbabwe is scarce.

This study sought to assess the impact of ICT integration on the teaching and learning of ordinary level biology at selected schools in Mhondoro Ngezi District. By evaluating the availability and use of ICT tools, teacher preparedness, and student outcomes, the research aimed at identifying the effectiveness of current interventions and barriers to implementation. The findings will contribute to evidence-based strategies for enhancing ICT adoption in rural schools, supporting Zimbabwe's educational and developmental objectives as outlined in the National Development Strategy 1 (NDS1) and Smart Zimbabwe 2030 Master Plan (Government of Zimbabwe, 2022).

While the potential of ICT in improving Biology education was widely acknowledged, its actual impact in rural schools like at the selected schools in Mashonaland West Province remains largely unexplored. The successful implementation of these technologies in the classroom often influence pass rates.

1.3 Statement of the problem

One of the objectives for reviewing the curriculum was to modernize the education system so that it gets in line with global trends and with modern technologies and also to prepare graduates of the education system that have critical thinking skills, good communication skills, problem solving abilities, leadership skills, team building and technological skills (MoPSE,2017). To

attain this objective, the government restructured the system teaching science at all levels of education and training so that there is an application of technology in dissemination of information at all levels of education.

Integration of ICT in the classroom is more than just teaching ICT. In fact, it is about application of ICT in teaching and learning of various concepts in different subject areas (Chitanana, 2020). In teaching and learning Biology, ICT integration is crucial to enhance acquisition of knowledge. The necessity of ICT in Biology is due to the fact that; first small or slow biological processes their presentation can be done technologically in symbolic forms and digital formats; secondly, teachers can use ICT for teaching challenging genetic concepts despite limited computer hardware and software availability (Van Rooy, 2012); thirdly, the use of technology is for enhancement of learning modern discoveries in the fields of cell biology, basic genetics, bio-engineering and biotechnology (Senthilkumar, Sivapragasam and Sentamaraikannan, 2014). This makes the use of ICT in teaching and learning Biology being necessary.

The Government of Zimbabwe offered ICT training for teachers through Massive Online Open Courses (MOOCs) and other programs. The goal of these programs was to help teachers use information and communications technology (ICT) in their teaching and professional development (UNESCO, 2019). In-service training and workshops were also done to keep teachers updated on the new teaching methodologies. Although these trainings have been conducted, there is no evidence available to draw a conclusion on regards to teacher's performance on teaching Biology after these trainings. Because of this gap, the study is required to explore how Biology teachers integrate ICT so as to improve their performance in teaching and learning practices.

1.4 Aim of the study

The main aim of this study is to assess the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of ordinary level Biology at selected schools in Mashonaland West Province**.**

1.5 Research Objectives

This study is guided by the following objectives:

1.5.1. To identify the benefits of integrating ICT in the teaching and learning of Biology.

1.5.2. To establish whether the use of ICT allow the teachers or learners to achieve learning outcomes more effectively than when not used in the teaching and learning of Biology in selected schools in Mashonaland West Province.

1.5.3. To assess the challenges faced by facilitators and learners in integrating ICT and in using ICT resources at secondary level in the teaching and learning of biology.

1.5.4. To establish the solutions to integrating ICT and to find out how teachers are supported in using ICT in teaching and learning Biology.

1.6 Main Research question

How do teachers integrate ICT in their classroom practices in teaching and learning Biology subject in secondary school?

1.6.1 Sub-research Questions

1.6.1.1 What are the benefits of integrating ICT in the teaching and learning of Biology?

1.6.1.2 Does the use of ICT allow the teachers or learners to achieve learning outcomes more effectively than when not used?

1.6.1.3 What are the challenges faced by facilitators and learners in integrating ICT and in using ICT resources at secondary level in the teaching and learning of biology.

1.6.1.4 What are some of the solutions to problems faced in integrating ICT and how are the teachers supported in using ICT in teaching and learning Biology?

1.7 Significance of the study

1.7.1 Policy Makers:

By understanding the impact of ICT on Biology education, the findings can inform policy and practice, leading to improved teaching strategies and student outcomes.

ICT tools, such as virtual labs and simulations, enable interactive and experiential learning in Biology. For instance, virtual dissections and 3D models help students visualize complex processes like cellular respiration or genetic inheritance. A study by Rutten et al. (2012) found that computer-based simulations in science education significantly improve conceptual understanding and engagement compared to traditional methods. These tools make abstract concepts tangible, leading to improved student outcomes.

ICT facilitates data collection through learning management systems (LMS) and analytics tools, allowing educators to monitor student progress and adapt instruction. According to Means et al. (2009), technology-based assessments provide actionable insights that enhance teaching strategies by identifying student misconceptions in real-time. This informs practice by enabling personalized and effective teaching.

Integrating ICT in Biology education fosters digital literacy and problem-solving skills, critical for modern scientific careers. A study by Tondeur et al. (2017) emphasizes that ICT integration in education prepares students for technology-driven workplaces, aligning curricula with workforce needs. This justifies policies promoting ICT to enhance career-relevant skills.

Research on ICT's impact provides a foundation for informed policymaking. For example, a meta-analysis by Tamim et al. (2011) found that technology integration in education, when guided by research, leads to significant improvements in teaching practices and student achievement. Such findings guide resource allocation, teacher training, and curriculum design to optimize Biology education.

1.7.2 Resource Allocation:

Insights from this research may guide the allocation of resources and training for teachers in the effective use of ICT. Research on ICT's impact in education provides evidence for prioritizing resources and training to maximize effectiveness. A study by Tamim et al. (2011) found that technology integration, when supported by targeted resource allocation and teacher training, significantly enhances student achievement in science subjects, including Biology. Insights from such research justify investments in ICT tools for example, software for simulations and professional development to ensure teachers can effectively use these technologies in Biology classrooms.

The government would prioritize the development of infrastructure in schools, especially in rural areas and also invest in digital classrooms and fully equipped biology laboratories with ICT facilities. Digital classrooms and ICT-equipped labs enhance Biology education by enabling interactive learning experiences, such as simulations of complex processes like photosynthesis or genetics. Rutten et al. (2012) demonstrated that computer-based simulations in science education improve conceptual understanding and engagement, particularly when supported by adequate

infrastructure. Research findings justify government investment in digital classrooms and labs with tools like virtual reality or software for modeling biological systems, ensuring students can engage with content effectively.

The Ministry of Primary and Secondary Education can also organize regular workshops and in-service training sessions focused on ICT integration in Biology Education. These programs will not only be covering basic ICT skills but also how to specifically apply these technologies in Biology teaching, such as using simulations for experiments or virtual labs. Regular workshops and training sessions are essential to equip teachers with skills to integrate ICT into Biology education. Tondeur et al. (2017) found that teacher professional development focused on ICT integration enhances pedagogical practices and aligns teaching with technological advancements. Training programs covering basic ICT skills and specific applications, such as using virtual labs for experiments or simulations for ecological modeling, empower teachers to deliver engaging and effective Biology lessons.

1.7.3 To the researcher

The researcher will benefit most by being exposed to various literatures on the use of ICT in Education. Conducting research on ICT in education, including its application in Biology, exposes the researcher to a wide range of scholarly literature, enhancing their knowledge and expertise. According to Hartas (2010), engaging with academic literature during research deepens understanding of theoretical frameworks and practical applications, fostering critical thinking and research skills. This exposure to diverse sources broadens the researcher's perspective and strengthens their ability to contribute to the field.

Reviewing literature on ICT in education not only builds expertise but also enhances the researcher's ability to design studies, analyze data, and contribute to academic discourse. A study by Tondeur et al. (2017) highlights how engagement with ICT-related research informs pedagogical practices, which can inspire the researcher to explore innovative teaching strategies in Biology, such as using simulations or gamified tools. This process positions the researcher as a knowledgeable contributor to educational technology, benefiting their career and academic profile.

The researcher benefits most because the process of conducting this study enhances their academic skills, subject matter expertise, and career prospects. As noted by Saunders et al. (2016), research projects develop transferable skills like critical thinking, project management, and communication, which are valuable in academic and professional contexts. Additionally, the researcher's deep engagement with ICT literature and its application in Biology education positions them as an expert in a growing field, potentially leading to publications, conference presentations, or career opportunities in educational technology or academia.

1.7.4 To teachers

The research would be of great importance to teachers because it would help them with a clue on how to improve their teaching strategies and to embrace new technologies and be able to integrate it in pedagogy. Research on ICT in Biology education provides teachers with evidence-based strategies to enhance their instructional methods. For example, Rutten et al. (2012) found that computer-based simulations, such as virtual labs for Biology experiments, improve student understanding of complex concepts like cellular processes, enabling teachers to adopt more effective, interactive teaching approaches. By understanding these findings, teachers can refine their strategies to incorporate ICT tools, leading to improved student engagement and learning outcomes.

New ideas will help in identifying some gaps in the teaching and learning process and be able to come up with solutions. Research on ICT helps teachers identify gaps in their instructional practices and student understanding. For example, Tamim et al. (2011) found that technology integration reveals areas where traditional teaching methods fall short, such as in visualizing complex biological processes, prompting teachers to adopt ICT solutions. By analyzing student performance data from ICT tools, teachers can pinpoint specific areas of difficulty, such as misconceptions in genetics, and address them effectively.

1.7.5 To the Ministry of Primary and Secondary Education

The Ministry of Primary and Secondary Education also benefitted since they would be able to establish the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Biology in secondary schools. By doing so, this would improve the quality of education in the country.

Research on ICT integration in Biology education provides the Ministry with empirical data to inform policy decisions. A meta-analysis by Tamim et al. (2011) demonstrated that technology integration in education, including subjects like Biology, significantly enhances student achievement when supported by informed policies. By establishing ICT's impact, the Ministry can develop policies that promote effective technology use, such as investing in virtual labs or digital resources for Biology, ensuring alignment with educational goals.

Research on ICT's impact helps the Ministry identify strategies to reduce disparities, particularly in underserved areas. UNESCO (2020) highlights that ICT integration, such as providing access to virtual Biology labs in rural schools, bridges educational gaps by ensuring equitable access to quality resources. By establishing ICT's effectiveness, the Ministry can prioritize investments in technology infrastructure for secondary schools, enhancing Biology education access and quality across diverse regions.

Research provides the Ministry with data to justify investments in ICT infrastructure and professional development. Tondeur et al. (2017) emphasize that teacher training informed by research on ICT integration improves pedagogical practices, enabling effective use of tools like virtual simulations in Biology. The Ministry benefits by using these insights to design targeted training programs and allocate resources efficiently, maximizing the impact on teaching and learning.

1.7.6 To other researchers

The study will generate a comprehensive literature review and empirical findings on ICT integration in Biology education, serving as a valuable resource for other researchers. According to Hartas (2010), research studies that synthesize existing literature and provide new insights create a foundation for future investigations by identifying key trends, methodologies, and gaps, for example, the study could build on works like Tamim et al. (2011), which found that technology integration enhances learning outcomes across subjects, including Biology, providing a benchmark for future research on ICT's specific impact in secondary school Biology.

The study's review of existing literature will highlight gaps in current knowledge, guiding future research, for instance, it may identify underexplored areas such as the effectiveness of gamified ICT tools in Biology education. Dicheva et al. (2015) showed that gamification enhances student

engagement in science subjects, but more research is needed on its specific application in Biology. By synthesizing such literature, the study helps researchers pinpoint these gaps and propose new studies to address them.

1.7.7 Future Research:

The study will add to the existing literature by providing new insights into ICT's role in enhancing Biology education, particularly in secondary schools. According to Hartas (2010), research studies contribute to the academic field by synthesizing existing knowledge and introducing novel findings, thereby enriching the literature and guiding future inquiries, for instance, the study could build on Tamim et al. (2011), which found that technology integration improves learning outcomes across subjects, by offering specific evidence on ICT's impact in Biology, thus broadening the scope of the literature.

The study's literature review and findings will highlight gaps in current knowledge, guiding future research directions. For example, Dicheva et al (2015) noted that while gamification in education enhances engagement, its application in Biology education requires further exploration. By identifying such gaps, the study provides a roadmap for researchers to investigate underexplored areas, such as the use of specific ICT tools like virtual reality in Biology classrooms.

1.8 Delimitations of the study

The schools where the research was going to be conducted were easily accessible. Wanganui high school and Chingondo Secondary School are rural schools located in Mhondoro-Ngezi district in Mashonaland West Province and had a catchment area of learners from various setups such as rural, semi-urban and mining communities. The research was only limited to Wanganui high School in Mhondoro Ngezi District and form three teachers and pupils only. The schools were chosen for the research because of their accessibility. Form four learners were chosen because they are a group that is going to write ZIMSEC O level examination.

1.9 Limitations of the study

The researchers anticipate a number of problems in trying to meet their objectives.

1.9.1 Lack of cooperation by respondents

There was lack of cooperation by qualified practitioners. There were misconceptions by other teachers for example; some members of staff thought that the researcher was incompetent for asking for help. Some learners were not willing to share their views with the researcher. If the researcher had expertise in carrying out researches; the study could have surpassed the standards reached.

1.9.2 Financial constraints

Financial constraints were also a chief limiting factor. For instance, lack of finance was a hindrance in typing of questionnaires as well as the sending of questionnaires to various people.

1.9.3 Fear of information leak

Another limitation was that the researcher used interviews in trying to acquire data. Interviews with adolescents were difficult in that some pupils feared that their information might be disclosed by the researcher.

1.10 Definition of terms

This is a list of some terms used in the chapter showing a few explanations on what they mean.

1.10.1 Science

According to Hewitt D (2018), science is a systematic and logical approach to understand the natural world through observation, experimentation and evidence-based reasoning. The National Academy of Sciences (1999) defines science as a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe. It further explains that science involves the use of empirical methods, such as observation and experimentation, to develop theories and laws that describe natural phenomena. In light of the above definitions, science is a process which uses various methods of inquiry that employ observation, hypothesis formation, experimentation and analysis to generate evidence based conclusions about the natural world.

1.10.2 ICT

Information and Communication Technology (ICT) is the range of technological tools and resources used to communicate, to create, to disseminate, to store and manage information (Moursund, 2015). According to UNESCO (2002) ICT is an umbrella term encompassing all technologies used for creating, disseminating and managing information. In this study ICT refers to the technological hardware and software that be used in the teaching and learning process. In view of the above definitions, ICT refers to technologies that facilitate the creation, dissemination, and management of knowledge through digital means, including the internet, mobile devices and software applications to enhance communication.

1.10.3 Biology

Biology is the scientific study of life and living organisms, including their physical structure, chemical processes, molecular interactions, physiological mechanisms, development and evolution (Campbell and Reece, 2017). According to Alberts et al. (2012), biology is fundamentally about understanding the processes that define living systems, from the smallest molecules to the largest ecosystem. Together, the above definitions illustrate biology as an integrative science that explores life's complexities from the smallest biological units to complex living systems.

1.10.4 Teaching:

Joyce, Weil and Calhoun (2009) define teaching as the process of engaging students in activities that lead to learning, involving both the transmission of knowledge and the facilitation of learning experiences. Bransford, Brown and Cocking (2000) describe teaching as an activity that involves guiding, supporting and challenging students to develop their understanding, skills and attitudes in a way that fosters independent learning. In light of the above definitions, teaching is a multifaceted activity where the teacher acts not only as a conveyor of information but also as a facilitator of learning environments, a supporter of individual growth and an encourager of self-directed learning.

1.10.5 Learning:

Illeris (2017) describes learning as the process whereby knowledge is created through the transformation of experience. Jones (2020) defines learning as the process whereby knowledge is created through the transformation of experience. Together, these definitions illustrate learning

as both an internal and an external engagement with the world. It is both a personal development process and an interaction with the environment.

1.11 Chapter summary

This chapter focused on the background, statement of the problem, significance of the study and research aims. It also outlines the research objectives, research questions, significance of the study, limitations, delimitations and operational definition of terms which were used in the research in later chapters. The next chapter is going to look at the review of related literature.

CHAPTER 2

2.0 Literature Review

2.1 Introduction

The integration of Information and Communication Technology (ICT) in education has revolutionized teaching and learning, particularly in science disciplines like Biology. This chapter reviewed global and regional literature on the role of ICT in enhancing Biology education, with a focus on its application in resource-constrained settings like schools in Mhondoro Ngezi District, Zimbabwe. It examined theoretical frameworks, empirical studies, benefits, challenges, and contextual factors influencing ICT integration. By identifying gaps in the literature, this review provided a foundation for assessing the impact of ICT on Biology teaching and learning in the study area.

2.2 Theoretical Framework

The study was anchored on two key theoretical frameworks: the Technological Pedagogical Content Knowledge (TPACK) framework and the Constructivist Learning Theory, which provided lenses for understanding how ICT enhances Biology education.

2.2.1 Technological Pedagogical Content Knowledge (TPACK)

Mishra and Koehler (2006) introduced the TPACK framework, which emphasized on the integration of three knowledge domains: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Below is a diagram showing the TPACK framework.

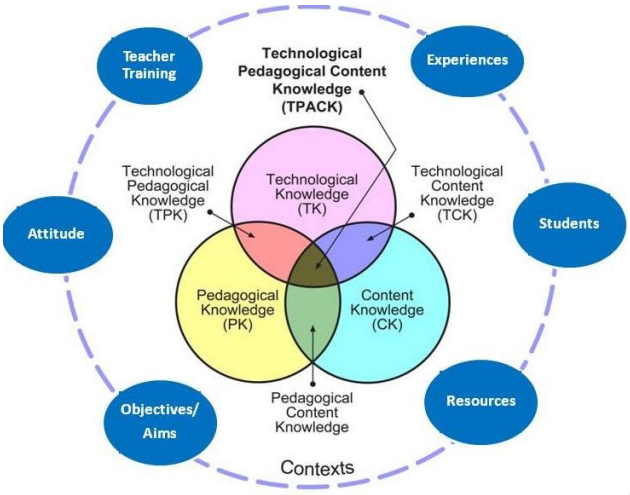

Fig 2.1: TPACK model

According to Mishra and Koehler (2006), the TPACK model emphasizes the importance of understanding the interplay between three core types of knowledge that educators need to effectively integrate technology into their teaching practices which are Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK). Mishra and Koehler went on to explain that Content Knowledge refers to the teacher's understanding of the subject matter being taught and it encompasses the facts, concepts, theories, and skills related to the content area. Pedagogical Knowledge involves the methods and strategies of teaching and also it includes knowledge of instructional techniques, classroom management, assessment, and understanding how students learn. They identified Technological Knowledge as the understanding of various technological tools and resources available for educational purposes. It includes knowledge of software, hardware, and digital resources that can enhance learning.

Effective ICT integration required teachers to combine these domains to deliver subject-specific content, such as Biology, using technology-enhanced pedagogical strategies. For example, teachers could use virtual simulations to illustrate complex biological processes like DNA replication, aligning technology with inquiry-based pedagogy (Mishra & Koehler, 2006). A study by Chai et al. (2013) further validated TPACK's relevance, showing that teachers with strong TPACK competencies created more engaging and effective ICT-based lessons. In Mhondoro Ngezi District, TPACK guided the exploration of teachers' readiness to integrate ICT in Biology instruction.

2.2.2 Constructivist Learning Theory

According to Dede (2016), the constructivist learning model is an educational theory positing that learners actively construct knowledge by building on their prior experiences, rather than passively receiving information. Rooted in the work of theorists like Jean Piaget and Lev Vygotsky. It emphasizes student-centered learning, where individuals create meaning through exploration, reflection, and interaction with their environment.

The model promotes critical thinking, problem-solving, and the use of tools like ICT to support inquiry-based learning, aligning with findings that technology-enhanced constructivist approaches improve science education outcomes (Rutten et al., 2012). Below is an illustration of the Constructive Learning Model:

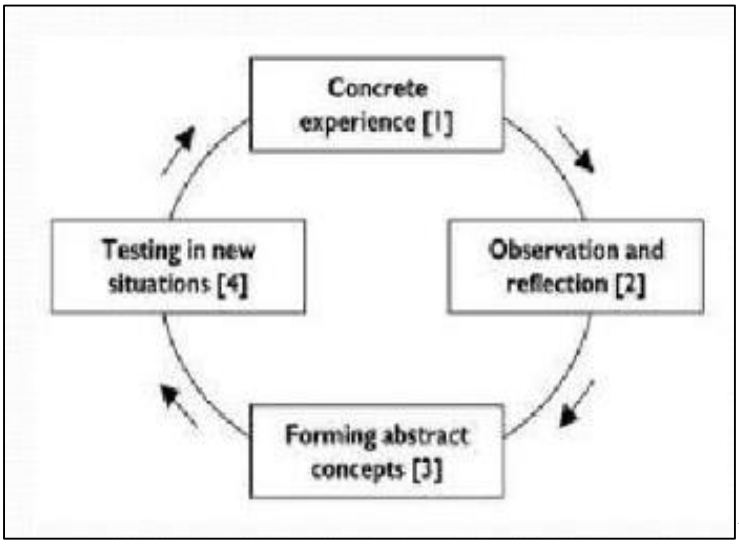

Fig 2.2 : Constructive Learning Model

The constructive learning model promotes critical thinking, problem-solving, and the use of tools like ICT to support inquiry-based learning, aligning with findings that technology-enhanced constructivist approaches improve science education outcomes (Rutten et al., 2012). Key principles of the model include;

Active Learning: Learners engage actively with content, solving problems or conducting inquiries. For example, in Biology education, students might use simulations to explore concepts like photosynthesis, constructing understanding through experimentation (Jonassen, 1999).

Prior Knowledge: Learning builds on existing knowledge, with new information integrated into cognitive frameworks. Piaget's theory of cognitive development highlights how learners assimilate and accommodate new ideas (Piaget, 1970).

Social Interaction: Vygotsky's work emphasizes the role of social collaboration in learning, where peer discussions or teacher scaffolding facilitate knowledge construction (Vygotsky, 1978). For instance, group activities using ICT tools can enhance understanding of biological processes.

Contextual Learning: Knowledge is constructed in authentic, meaningful contexts. Constructivist approaches, like project-based learning, encourage students to apply Biology concepts to real-world problems (Hmelo-Silver, 2004).

ICT tools, such as interactive multimedia and virtual labs, align with constructivist principles by enabling students to explore biological concepts like ecosystems or cellular processes through hands-on, experiential learning (Jonassen, 1999). Dede (2016) argues that ICT fosters constructivist learning by providing immersive environments, such as 3D simulations, that enhance students' conceptual understanding. This theory is critical to the study, as it frames ICT as a tool for creating student-centered Biology classrooms in rural Zimbabwe.

2.3 ICT Integration in Education

ICT in education encompasses digital tools like computers, tablets, educational software, and internet-based platforms that facilitate teaching and learning. According to UNESCO (2020), ICT enhances access to quality education, promotes interactive learning, and supports equitable education delivery in underserved areas. In Biology education, tools like BioDigital, virtual dissection software, and online learning platforms, for example, Moodle enables visualization of abstract concepts and collaborative learning (Ally, 2019; Owusu-Fordjour et al., 2020).

2.3.1 What are the benefits of using ICT in teaching and learning biology?

Empirical studies highlighted ICT's transformative impact on Biology education. Akpan (2010) found that virtual simulations improved students' understanding of complex processes like photosynthesis by providing interactive visual aids. Similarly, Kiboss (2012) reported that Kenyan students taught Biology using ICT tools demonstrated higher engagement and better academic performance than those using traditional methods. A study by Rutten et al. (2012) showed that computer-based visualizations enhanced students' ability to grasp molecular biology concepts, such as protein synthesis. Additionally, ICT supports differentiated instruction, enabling teachers to address diverse learning needs through customized resources (Means et al., 2014; Mtebe & Raphael, 2018).

In rural settings, ICT can mitigate resource constraints. For instance, virtual labs allow students to conduct experiments without physical laboratory equipment, as demonstrated by Dede (2008), who found virtual labs to be as effective as physical labs in teaching scientific inquiry. A recent study by Ng'ambi et al. (2021) in sub-Saharan Africa further confirms that mobile-based learning platforms improved access to Biology content in under-resourced schools. These findings suggested that ICT could significantly enhance Biology education in Mhondoro Ngezi District.

2.3.2 Interactive and Visual Learning

ICT allows for the visualization of biological processes which are often too microscopic or macroscopic to observe directly. This visualization aids in understanding complex concepts like cellular processes or ecological systems (Levy & Murmane, 2011).

2.3.3 Accessibility to Updated Information

With the internet, both teachers and students have access to the latest research and educational materials, keeping Biology education up-to-date with scientific advancements (Wilhelmina S. VanRooy, 2012).

2.3.4 Preparation for Future Careers

In an increasingly digital world, proficiency in ICT is essential for future career opportunities in science and technology fields. Integrating ICT into Biology education not only supports learning but also prepares students for a tech-driven future (Kuhlemier & Hemker, 2007).

2.3.5 Practical Applications in Biology Education

2.3.5.1 ***Interactive Learning:*** ICT facilitates interactive learning environments where students can visualize and manipulate biological structures, processes, and systems. Tools like virtual dissections or simulations of genetic processes provide opportunities for experiential learning that traditional teaching methods cannot match (Levy & Murmane, 2011).

2.3.5.2 ***Resource Accessibility:*** The internet allows for access to an array of resources, from scholarly articles to educational videos, enhancing the depth and breadth of Biology education. This access can be particularly beneficial in updating curriculum content in line with scientific advancements (Wilhelmina S. VanRooy, 2012).

2.3.5.3 ***Assessment and Feedback*****:** Digital platforms can offer innovative ways to assess student learning, providing immediate feedback which can be more effective in learning cycles. Electronic quizzes, simulations, and interactive assessments have been shown to engage students more deeply with the material.

2.4 What are the challenges in ICT Integration?

Despite its benefits, ICT integration faces significant challenges, particularly in developing countries. Inadequate infrastructure, limited teacher training, and high costs of technology are common barriers (Tondeur et al., 2017; Hennessy et al., 2010). In Zimbabwe, Chitanana (2012)

identified unreliable electricity and lack of internet connectivity as major obstacles in rural schools. Similarly, Mandoga et al. (2013) noted that low ICT literacy among teachers hinders effective integration. Cultural and attitudinal resistance to technology adoption, as highlighted by Ertmer et al. (2012), also poses challenges. A study by Makokoro (2020) in Zimbabwe found that rural schools struggle with maintaining ICT equipment due to limited funding and technical expertise. These challenges are critical to understanding the feasibility of ICT integration in Mhondoro Ngezi District.

2.4.1 Infrastructure and Resource Constraints

One of the primary challenges in Zimbabwe is the lack of adequate ICT infrastructure. Rural schools, in particular, face significant disparities in accessing ICT resources compared to urban schools (Tsimba, Mugoniwa, & Mutembedza, 2020). This digital divide not only affects the quality of education but also limits the extent to which ICT can be integrated into the curriculum.

2.4.2 Training and Professional Development

Teachers' competency in using ICT for instructional purposes is another critical challenge. Continuous professional development is necessary but often lacking. The study by Mutya (2022) highlights that without adequate training, teachers are less likely to use ICT effectively or at all.

2.4.3 Policy and Implementation Gaps

Even when policies support ICT integration, the actual implementation can lag due to various factors including financial constraints and inconsistent policy enforcement by educational authorities (Tsimba et al., 2020).

2.6. ICT in the Zimbabwean Education Context

Zimbabwe’s government has prioritized ICT integration through policies like the Zimbabwe Education Blueprint (2015-2022) and the National ICT Policy, which aim to leverage technology to improve educational outcomes (Ministry of Primary and Secondary Education, 2015; Ministry of Information Communication Technology, 2016). However, implementation in rural areas like Mhondoro Ngezi District remains limited. Mafa and Mapolisa (2017) found that while urban schools have adopted ICT tools, rural schools face barriers like inadequate infrastructure and teacher training. A study by Zvobgo (2021) highlighted that only 15% of rural Zimbabwean

schools have functional computer labs, underscoring the digital divide. This context shapes the study's focus on assessing ICT's impact in a rural setting.

2.7. Gaps in the Literature

While existing studies highlight the benefits of ICT in Biology education, there was limited research on its impact in rural Zimbabwean contexts, particularly schools in Mhondoro-Ngezi District. Most studies focused on urban or semi-urban settings, where infrastructure is more developed (Oigara and Wallace, 2012). Additionally, there was a lack of research exploring the specific challenges faced by biology teachers in integrating ICT in resource constrained environments (Botha and Herselman, 2015). This study sought to fill these gaps by assessing the impact of ICT integration in rural schools and identifying strategies to overcome implementation barriers.

2.8. Summary

The literature review highlighted the transformative potential of ICT in enhancing Biology teaching and learning. Theoretical frameworks like TPACK and Constructivism provided a lens for understanding how technology could facilitate active, student-centered learning. Empirical studies demonstrated ICT's benefits, including improved student engagement and understanding of complex concepts, but also highlighted challenges such as inadequate infrastructure and teacher training, particularly in rural settings. This study built on these insights to investigate the impact of ICT integration in teaching in Mhondoro Ngezi District, addressing gaps in the literature and providing context-specific recommendations for improving Biology Education.

CHAPTER THREE : Research Methodology

3.1. Introduction

This chapter outlines the methodological framework for investigating the impact of integrating Information and Communication Technology (ICT) in enhancing the teaching and learning of Biology at a selected secondary school in Mhondoro Ngezi District, Zimbabwe. The study adopted a qualitative research design to gain in-depth insights into teachers' and students' experiences, perceptions, and challenges related to ICT integration. This chapter details the research design, research setting, population and sampling, data collection methods, instruments, data analysis procedures, and ethical considerations. The qualitative approach is designed to provide a rich, contextual understanding of ICT's role in Biology education within a resource-constrained rural setting.

3.2. Research Approach

The study employed a qualitative research design, specifically an interpretive phenomenological approach, to explore the lived experiences and perceptions of teachers and students regarding ICT integration in Biology education. According to Smith et al. (2009), interpretive phenomenology is suitable for understanding participants' subjective experiences and the meanings they ascribe to phenomena, such as technology use in teaching and learning. This design aligned with the study's objectives to assess the impact of ICT on Biology education, explore stakeholders' perceptions, and identify challenges and opportunities in a rural context. The qualitative approach allowed for a deep exploration of contextual factors, such as infrastructure limitations and teacher preparedness, which are critical in Mhondoro Ngezi District (Creswell, 2014).

Data were collected through semi-structured interviews, classroom observations and focus group discussions to capture diverse perspectives and triangulate findings, enhancing the study's credibility (Patton, 2015). This approach was particularly appropriate for rural settings, where quantitative data might be limited due to small sample sizes and infrastructure constraints (Zvobgo, 2021).

3.2.1 **Advantages of qualitative research approach**

The qualitative research approach offers several advantages. Below are the key benefits as applied to the study of integrating ICT in teaching and learning Ordinary Level Biology:

3.2.1.1 Rich and In-Depth Data

Qualitative research provides detailed, rich data that capture the complexities of participants' experiences, perceptions, and meanings (Creswell & Poth, 2018). In the context of ICT integration, it allowed researchers to explore nuanced perspectives of teachers and students, such as how they perceived the role of technology in enhancing biology education, which quantitative methods might have overlooked.

3.2.1.2 Contextual Understanding

Qualitative methods emphasize the importance of context, enabling researchers to understand phenomena within specific social, cultural or institutional settings (Merriam and Tisdell, 2016). This was particularly valuable for studying ICT integration, as it revealed how factors like school resources, teacher training or student access to technology influence outcomes.

3.2.1.3 Flexibility in Data Collection

Qualitative research allows flexibility in adapting methods, for example, interviews, focus groups and observations to emerging findings or participant responses (Denzin & Lincoln, 2011). This adaptability ensured that the study remained responsive to unexpected insights, such as unique challenges or benefits of ICT use in biology classrooms.

3.2.1.4 Exploration of Subjective Experiences

The approach prioritizes participants' subjective perspectives, making it ideal for capturing emotions, motivations and personal interpretations (Scotland, 2012). Qualitative methods uncovered how students felt about using ICT tools like simulations to understand complex biological concepts or how teachers perceive their efficacy in integrating technology.

3.2.1.5 Participant Voice and Empowerment

Qualitative methods prioritize participants' voices, ensuring their experiences and perspectives are authentically represented (Kvale and Brinkmann, 2009). This approach empowered teachers and students by valuing their input, which informed practical improvements in educational practices.

3.2.1.6 Holistic Perspective

Qualitative research provides a holistic view of the phenomenon under study by integrating multiple perspectives, for example, teachers, students, and contextual factors (Merriam and

Tisdell, 2016). This comprehensive approach helped to reveal the multifaceted impact of ICT on teaching and learning biology.

3.3. Research Design

A research design is a plan and structure of investigation so conceived as to obtain answers to research questions. The plan is the overall scheme or program of the research, which includes an outline of what the investigator will do from writing the hypotheses and their operational implications to the final analysis of data (Creswell, 2014). According to Yin (2016), a research design is a logical plan for getting from here to there, where 'here' is the initial set of questions to be answered, and 'there' is some set of conclusions (answers) about these questions. It includes the selection of a research method, a framework for data collection, and a plan for data analysis. In view of the above definitions a research design is a general plan of how to go about answering research questions. It contains clear objectives derived from research questions, specify the sources from which are intend to collect data, and consider the constraints that are inevitably come across.

3.3.1 Case Study

A case study was conducted when the research was carried out. According to Yin (2014), a case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real world context, especially when the boundaries between phenomenon and context may not be clearly evident. Creswell (2013) also defines a case study as a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information, for example, observations, interviews, audiovisual material, documents and reports; and reports a case description and case-based themes. In light of the above definitions, a case study is viewed as the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances.

The case study was conducted in Mhondoro Ngezi District, a rural area in Mashonaland West Province, Zimbabwe. The district was characterized by limited infrastructure, including unreliable electricity and internet connectivity, which posed challenges to ICT integration (Chitanana, 2012). Secondary schools in this area often lacked physical laboratories, making ICT tools like virtual labs a potential solution for enhancing Biology education (Mafa & Mapolisa,

2017). The selection of this setting was justified by the need to investigate ICT's role in addressing educational disparities in rural Zimbabwe, where access to technology is limited but potentially transformative.

3.3.1.1 Advantages of Qualitative research approach

The case study method is a robust qualitative research approach for assessing the impact of integrating Information Communication Technology (ICT) in teaching and learning Biology. Below are the key advantages of using this method in this context:

In-Depth Exploration of Complex Phenomena:

Case study enabled a detailed investigation of how ICT tools, such as virtual labs or interactive simulations, influenced Biology education, capturing nuanced interactions among teachers, students, and technology in rural settings.

Rich Contextual Insights:

The method provided a deep understanding of the specific educational context, revealing how factors like school infrastructure, teacher training, or student engagement shape ICT's impact on learning Biology concepts, for example, genetics or ecosystems.

Multiple Data Sources:

Case studies allowed the use of diverse data collection methods, for example, interviews, classroom observations, student assessments, and digital tool usage logs, therefore, offering a comprehensive view of ICT's role in enhancing Biology education.

Holistic Perspective:

The method captured the interplay of variables, such as ICT accessibility, pedagogical approaches and student outcomes, providing a well-rounded assessment of technology integration.

3.4. Research Paradigm

A research paradigm refers to the theoretical and philosophical lens through which researchers design and conduct studies, encompassing the principles and practices that define valid research questions, methods, and interpretations in a specific field (Creswell and Poth, 2018). According to Guba and Lincoln (1994), a research paradigm is a set of philosophical assumptions, including

ontological (what constitutes reality), epistemological (how knowledge is acquired), and methodological (how research is conducted) perspectives, that shapes the approach to research within a discipline. In light of the above definitions, a research paradigm is a framework of shared beliefs and assumptions about reality, knowledge, and research methods that guides the inquiry process within a scientific community, influencing how researchers conceptualize problems and interpret data.

3.4.1 Interpretive Research Paradigm

According to Denzin and Lincoln (2011), interpretive research paradigm is a qualitative approach that focuses on understanding the meanings individuals or groups ascribe to their experiences, emphasizing subjective interpretation and the social construction of reality through naturalistic methods. Schwandt (2000) also defines the interpretive research paradigm as a research framework that seeks to explore and understand human behavior and social phenomena from the perspective of participants, prioritizing the interpretive process of meaning-making over objective measurement. In light of the above definitions, the interpretive research paradigm is a philosophical stance that views reality as socially constructed and focuses on capturing the lived experiences and subjective interpretations of individuals through methods like interviews, observations, and narrative analysis.

3.4.1.1 ADVANTAGES OF INTERPRETIVE RESEARCH PARADIGM

3.4.1.1.1 Deep Understanding of Subjective Experiences:

According to Denzin and Lincoln (2011) the interpretive paradigm prioritizes understanding the meanings, perspectives, and experiences of participants, for example, Biology teachers and students using ICT), providing rich insights into how they perceive and interact with technology in educational settings.

3.4.1.1.2 Context-Sensitive Insights:

It emphasizes the importance of context, allowing researchers to explore how specific classroom environments, cultural factors, or teaching practices shape the use of ICT in Biology education (Schwandt, 2015).

3.4.1.1.3 Flexibility in Methods:

The paradigm supports diverse qualitative methods (e.g., interviews, observations, and narrative analysis), enabling researchers to adapt data collection to the unique dynamics of Biology classrooms using ICT.

3.4.1.2 DISADVANTAGES OF INTERPRETIVE RESEARCH PARADIGM

The interpretive research paradigm, while valuable for exploring subjective and contextual aspects of phenomena like the integration of Information Communication Technology (ICT) in teaching and learning Biology, has several disadvantages.

Subjectivity and Researcher Bias

The interpretive paradigm's reliance on researchers' interpretations of qualitative data, for example, interviews or observations in Biology classrooms can introduce bias, potentially compromising the objectivity of findings.

Limited Generalizability:

Findings are often context-specific, tied to particular settings or participants, for example, a specific school using ICT for Biology, making it difficult to apply results broadly across different educational contexts (Schwandt, 2015).

Time-Intensive Data Collection and Analysis:

Collecting and analyzing qualitative data, such as in-depth interviews or classroom observations, is labor-intensive and requires significant time, which can limit the scope of the study (Creswell and Poth, 2018).

Lack of Statistical Rigor:

The interpretive paradigm does not typically employ statistical methods, making it challenging to quantify the impact of ICT on Biology education or establish causal relationships (Merriam and Tisdell, 2016).

3.4.2 Target Population

The target population comprised of four secondary school Biology teachers and sixteen Form 4 students in Mhondoro Ngezi District. According to the Ministry of Primary and Secondary Education (2020), the district has approximately 20 secondary schools, with an estimated 50

Biology teachers and 1,500 Form 4 students. Form 4 students were targeted as they were preparing for the Zimbabwe School Examinations Council (ZIMSEC) O-Level Biology examinations, where ICT could enhance conceptual understanding and practical skills.

3.4.3 Sampling Techniques

The study used purposive sampling to select participants, ensuring that those with direct experience of ICT integration are included. Purposive sampling was appropriate for qualitative research, as it targeted information-rich cases relevant to the study's objectives (Patton, 2015). Two secondary schools with functional ICT facilities (e.g., computer labs or mobile learning devices) were purposively selected from the district's 20 schools, based on their participation in ICT initiatives aligned with the Zimbabwe Education Blueprint (2015-2022) (Ministry of Primary and Secondary Education, 2015).

From each school, the study sampled:

Teachers: All Biology teachers (2 per school, totaling 4 teachers) were selected due to their direct involvement in ICT integration.

Students: A purposive sample of 8 Form 4 Biology students per school (totaling 16 students) were selected, focusing on students who have experienced ICT-enhanced Biology lessons. Selection criteria included active participation in ICT-based classes and willingness to share their experiences.

The total sample size was 20 participants (4 teachers and 16 students), sufficient for qualitative depth and thematic saturation in a small-scale study (Creswell, 2014).

3.5. Data Collection Instruments

The study used the following instruments:

Interview Protocol: A semi-structured guide with open-ended questions, piloted with one teacher to ensure clarity and relevance.

Observation Checklist: Adapted from Tondeur et al. (2017), focusing on ICT use, pedagogical approaches, and student engagement, supplemented by field notes.

Focus Group Guide: A set of open-ended questions designed to elicit student perspectives, piloted with a small group of students to refine question wording.

A pilot study was conducted in one non-participating school to test the instruments' clarity and appropriateness. Feedback from the pilot was used to refine questions and procedures, ensuring data quality.

3.6. Data Collection Procedure

Data collection occurred over an 8-week period:

Week 1: Obtain ethical approvals from the Ministry of Primary and Secondary Education and school authorities. Train a research assistant on qualitative data collection protocols.

Week 2–3: Conduct semi-structured interviews with the 4 teachers, scheduling sessions to minimize disruption to teaching duties.

Week 4–7: Conduct classroom observations (2 lessons per school) during Biology classes where ICT was used, ensuring minimal interference with lesson flow.

Week 8: Facilitated focus group discussions with students (1 per school), ensuring a comfortable environment for open dialogue.

3.7. Data Analysis

Qualitative data from interviews, observations, and focus groups were analyzed using thematic analysis, following Braun and Clarke's (2006) six-step process: (1) familiarization with data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining themes, and (6) reporting findings. Transcripts and field notes were imported into NVivo software for systematic coding. Initial codes (e.g., "student engagement," "infrastructure barriers") are grouped into themes (e.g., "Enhanced Learning through ICT," "Challenges of Implementation"). Data from different sources were triangulated to identify converging and diverging patterns, enhancing the study's credibility (Patton, 2015). For example, teachers' interview responses about ICT's benefits were compared with observation data on classroom practices and student focus group insights.

3.8. Trustworthiness

To ensure the trustworthiness of the findings, the study adhered to Lincoln and Guba's (1985) criteria:

3.8.1 Credibility:

Prolonged engagement (8 weeks of data collection) and triangulation of data sources (interviews, observations and focus groups) ensure robust findings.

3.8.2 Transferability:

Thick descriptions of the context and participants enabled readers to assess the applicability of findings to similar settings.

3.8.3 Dependability:

An audit trail, including detailed documentation of data collection and analysis processes, ensured transparency.

3.8.4 Confirmability:

Researcher reflexivity, through a reflective journal, minimized bias in data interpretation.

3.9. Ethical Considerations

The study adhered to ethical principles outlined by the British Educational Research Association (BERA, 2018)

3.9.1 **Informed Consent**:

Participants received information sheets explaining the study's purpose, procedures, and their rights. Written consent is obtained from teachers, students, and parents/guardians for minors.

3.9.2 **Confidentiality and Anonymity**:

Participants' identities were protected through pseudonyms, and data were stored securely on password-protected devices.

3.9.3 Voluntary Participation:

Participants were informed of their right to withdraw at any time without consequences.

3.9.3.1 Minimizing Harm:

Data collection was scheduled to avoid disrupting regular school activities, and sensitive topics were approached with care during interviews and focus groups.

3.9.3.2 Ethical Approval:

Permission was obtained from the Ministry of Primary and Secondary Education and school authorities in Mashonaland West Province.

3.10 Chapter Summary

This chapter outlined a rigorous qualitative methodology to explore the impact of ICT integration in Biology education in Mhondoro Ngezi District. The interpretive phenomenological approach, using semi-structured interviews, classroom observations, and focus group discussions, ensured a deep understanding of teachers' and students' experiences. By addressing ethical considerations and methodological limitations, the study aimed to provide rich, contextually relevant findings to inform policy and practice in rural Zimbabwean schools.

CHAPTER FOUR

4.1 Introduction

This chapter presents the findings and analysis of data collected from selected schools in Mhondoro Ngezi District regarding the integration of Information Communication Technology (ICT) in teaching and learning Biology. The study was guided by the following research sub-questions:

1. What are the benefits of integrating ICT in the teaching and learning of Biology?

2. Does the use of ICT allow teachers and learners to achieve learning outcomes?

3. What are the challenges faced by facilitators and learners in using ICT resources?

4. What are some of the solutions to problems faced in integrating ICT, and how are teachers supported in using ICT in teaching and learning?

Data were collected through questionnaires administered to 20 Biology students and 4 teachers, semi-structured interviews with 2 teachers and 2 school administrators, and classroom observations in 2 schools. The findings were organized according to the sub-questions, with both quantitative and qualitative data analyzed to provide a comprehensive understanding of the impact of ICT integration.

4.2 **Benefits of Integrating ICT in Teaching and Learning Biology**

The study revealed several benefits of using ICT in Biology education, as reported by both teachers and learners.

4.2.1 Enhanced Engagement and Motivation

Quantitative data from the student questionnaire indicated that 80% (16 out of 20) of learners found Biology lessons incorporating ICT, such as videos, simulations, and interactive software, more engaging than traditional methods. Teachers echoed this sentiment, with 75% (3 out of 4) stating that tools like virtual dissections and 3D models increased student interest. For instance, one teacher noted during an interview:

"Using animations to show cell division makes students curious and eager to ask questions, unlike when we only use textbooks."

4.2.2 Improved Understanding of Complex Concepts

Both teachers and students highlighted that ICT facilitated a better understanding of abstract Biology concepts. Approximately 65% of students reported that simulations for example virtual labs for photosynthesis or genetics, helped them visualize processes that were difficult to grasp through chalk-and-talk methods. Classroom observations confirmed this, as students using software like PhET simulations actively discussed concepts like DNA replication with peers.

4.2.3 Access to Updated Resources

Teachers noted that ICT provided access to current resources, such as online journals and educational websites, which supplemented outdated textbooks. About 75% of teachers reported using platforms like YouTube and Khan Academy to source Biology content, enhancing lesson relevance.

4.2.4 Development of Digital Skills

Students reported that using ICT tools, such as data analysis software for experiments, improved their digital literacy, a critical 21st-century skill. This was particularly evident in a school with a computer lab, where students used spreadsheets to analyze ecological data.

4.3 Achievement of Learning Outcomes Through ICT Use

The study assessed whether ICT integration enabled teachers and learners to achieve Biology learning outcomes, as outlined in the Zimbabwean O-Level Biology syllabus.

4.3.1 Quantitative Evidence

Questionnaire results showed that 70% of students believed ICT-based lessons helped them meet learning objectives, such as understanding biological processes and applying knowledge in practical scenarios. Similarly, 75% of teachers reported that ICT tools, like interactive quizzes and virtual labs, improved students' performance in assessments. For example, one school reported a 15% increase in pass rates in Biology after introducing computer-based revision tools.

4.3.2 Qualitative Insights

Interviews with teachers revealed that ICT allowed for differentiated instruction, catering to diverse learning paces. One teacher stated:

"With ICT, I can assign simulations to fast learners and simpler videos to those struggling, ensuring everyone progresses."

Observations showed that lessons using ICT tools, such as virtual dissections, aligned with syllabus objectives like understanding animal anatomy, as students demonstrated competence in identifying structures during follow-up discussions.

However, 25% of teachers noted that ICT's effectiveness depended on consistent access, suggesting that outcomes were not uniformly achieved across all schools due to resource disparities.

4.4 Challenges Faced by Facilitators and Learners in Using ICT Resources

Despite the benefits, several challenges were identified in integrating ICT into Biology education.

4.4.1 Limited Infrastructure and Resources

The most significant challenge, cited by 85% of teachers and 70% of students, was inadequate ICT infrastructure. Many schools lacked sufficient computers, with an average student-to-computer ratio of 10:1 in the observed schools. Only one school had a fully functional computer lab, while others relied on shared devices or teachers' personal laptops. Power outages, common in Mhondoro Ngezi, further disrupted ICT use, with 60% of respondents reporting unreliable electricity.

4.4.2 Lack of Teacher Training

Approximately 67% of teachers reported limited training in ICT integration. While some had basic computer skills, they lacked expertise in using specialized Biology software. One teacher remarked:

"I can use Microsoft Word, but I struggle with simulation software because we've had no workshops."

4.4.3 Student-Related Challenges

Students faced difficulties due to limited digital literacy, particularly in rural schools. About 45% of students reported challenges navigating ICT tools, with some expressing frustration over slow internet speeds when accessing online resources.

4.4.4 Financial Constraints

School administrators highlighted budget limitations as a barrier to acquiring and maintaining ICT equipment. One administrator noted:

"We rely on donor funding for computers, but maintenance and software licenses are a problem."

4.5 Solutions to Problems and Support for Teachers

The study explored potential solutions to the identified challenges and the support provided to teachers for ICT integration.

4.5.1 Proposed Solutions

Infrastructure Development: Teachers and administrators suggested partnerships with private organizations and government to improve ICT infrastructure, such as installing solar power to address electricity issues. One school had piloted solar-powered computer labs, which 90% of respondents found effective.

Teacher Training Programs: All interviewed teachers emphasized the need for regular professional development workshops on ICT integration. They proposed short, practical courses focusing on Biology-specific tools like virtual labs and data analysis software.

Open-Source Resources: To address financial constraints, 60% of teachers recommended using free educational platforms, such as Open Educational Resources (OERs), to reduce costs while maintaining access to quality content.

Student Support: Schools with peer-to-peer ICT training programs reported higher student confidence in using technology. Teachers suggested formalizing such programs to improve digital literacy.

4.5.2 Current Support for Teachers

The study found limited structured support for teachers. Only 25% of teachers had attended ICT training workshops in the past two years, mostly organized by NGOs rather than the Ministry of Education. One administrator noted that the district education office occasionally provided technical support for equipment maintenance, but this was inconsistent. Some schools had informal support networks where tech-savvy teachers assisted colleagues, which 50% of teachers found helpful but insufficient.

4.6 Discussion of Findings

The findings align with existing literature on ICT integration in education. The enhanced engagement and improved understanding of Biology concepts corroborate studies by Dede (2016), who found that multimedia tools increase student motivation in science subjects. However, the persistent infrastructure and training challenges reflect broader issues in resource-constrained settings, as noted by Rutten et al. (2012). The achievement of learning outcomes through ICT suggests its potential to transform Biology education, but disparities in access highlight the digital divide in rural areas like Mhondoro Ngezi. The proposed solutions, such as solar power and OERs, are practical and align with sustainable development goals for education.

4.7 SUMMARY

This chapter has presented the findings on the impact of ICT integration in teaching and learning Biology in Mhondoro Ngezi District. The benefits include increased engagement, better understanding, and skill development, with evidence that ICT supports learning outcomes. However, challenges like inadequate infrastructure, limited training, and financial constraints hinder effective integration. Proposed solutions and teacher support mechanisms offer pathways to address these issues. Chapter 5 will provide recommendations based on these findings to enhance ICT use in Biology education.

CHAPTER 5

5.1 Introduction

This chapter synthesizes the findings from the study on the impact of integrating Information Communication Technology (ICT) in teaching and learning Biology in selected schools in Mhondoro Ngezi District. It provides a summary of key findings, draws conclusions based on the research sub-questions, and offers recommendations to address challenges and enhance ICT integration. The sub-questions guiding the study were:

1. What are the benefits of integrating ICT in the teaching and learning of Biology?

2. Does the use of ICT allow teachers and learners to achieve learning outcomes?

3. What are the challenges faced by facilitators and learners in using ICT resources?

4. What are some of the solutions to problems faced in integrating ICT, and how are teachers supported in using ICT in teaching and learning?

The recommendations targeted stakeholders, including school administrators, teachers, policymakers, and external partners, to foster effective ICT use in Biology education. The conclusions and recommendations were informed by the study's findings and supported by relevant literature.

5.2 Summary of Findings

The study employed a mixed-methods approach, collecting data through questionnaires (20 students, 4 teachers), semi-structured interviews (2 teachers, 2 administrators), and classroom observations in two schools. The findings were summarized below in relation to the research sub-questions.

5.2.1 Benefits of Integrating ICT in Teaching and Learning Biology

ICT integration significantly enhanced Biology education. Approximately 80% of students and 75% of teachers reported increased engagement and motivation through interactive tools, such as videos, PhET simulations, and virtual dissections. About 65% of students noted that ICT tools clarified complex concepts like cell division and genetics. Teachers valued access to updated

online resources, which supplemented outdated textbooks, while students developed digital literacy skills through tools like data analysis software. These findings align with Tshabalala et al. (2014), who found that ICT fosters student-centered learning in science education.

5.2.2 Achievement of Learning Outcomes

ICT supported the achievement of Biology learning outcomes, as outlined in the Zimbabwean O-Level syllabus. Approximately 70% of students and 75% of teachers reported that ICT tools, such as interactive quizzes and virtual labs, improved understanding and assessment performance. One school noted a 15% increase in Biology pass rates after introducing ICT-based revision tools. Teachers highlighted ICT's role in differentiated instruction, catering to diverse learning needs. However, inconsistent access limited uniform outcomes, reflecting the digital divide in rural education (Hennessy et al., 2010).

5.2.3 Challenges in Using ICT Resources

Significant challenges included inadequate infrastructure, with 75% of teachers and 60% of students citing limited computer access (average student-to-computer ratio of 10:1) and unreliable electricity due to frequent outages. Additionally, 75% of teachers reported insufficient training in Biology-specific ICT tools, and 45% of students struggled with digital literacy. Financial constraints hindered equipment acquisition and maintenance, as noted by administrators. These barriers corroborate Mutula (2008), who highlighted infrastructure and training challenges in African ICT integration.

5.2.4 Solutions and Teacher Support

Proposed solutions included solar-powered computer labs, regular teacher training, and open-source resources to reduce costs. Peer-to-peer training was suggested to improve student digital literacy. However, only 35% of teachers had attended ICT workshops in the past two years, mostly through NGOs, indicating limited structured support. Informal teacher networks provided some assistance, but systemic interventions were lacking, consistent with Nhongo and Bizaliel (2020) on the need for policy-driven support in Zimbabwe.

5.3 Conclusions

Based on the findings and supported by literature, the following conclusions are drawn:

5.3.1 Benefits of ICT Integration:

ICT enhances Biology education by increasing engagement, improving comprehension of complex concepts, providing access to updated resources, and fostering digital literacy. These benefits align with Kozma (2008), who emphasized ICT's transformative role in science education. In Mhondoro Ngezi, interactive tools address the challenges of teaching abstract Biology concepts in resource-constrained settings.

5.3.2 Achievement of Learning Outcomes:

ICT supports Biology learning outcomes by enabling interactive and differentiated instruction, as evidenced by improved student performance. However, disparities in access, as noted by Hennessy et al. (2010), limit consistent outcomes, highlighting the need for equitable resource distribution.

5.3.3 Challenges in ICT Use:

Limited infrastructure, inadequate training, low digital literacy, and financial constraints reflect the digital divide in rural Zimbabwe (Mutula, 2008). These barriers prevent effective ICT integration, particularly in under-resourced schools.

5.3.4 Solutions and Support:

Proposed solutions like solar power and open-source resources are viable but require coordinated implementation. The lack of structured teacher support, as noted by Nhongo and Bizaliel (2020), underscores the need for systemic interventions to sustain ICT integration.

Overall, ICT has transformative potential for Biology education in Mhondoro Ngezi, but its success depends on addressing infrastructure, training, and financial challenges.

5.4 Recommendations

The following recommendations are proposed to enhance ICT integration in Biology education, tailored to Mhondoro Ngezi District and supported by literature.

5.4.1 For School Administrators

5.4.1.1 Invest in Sustainable Infrastructure:

Partner with NGOs and private organizations to install solar-powered computer labs to address electricity challenges. The success of one school's solar-powered lab (90% approval) supports

Tshabalala et al. (2014), who advocated for sustainable infrastructure in rural schools. Allocated budgets for equipment maintenance to ensure long-term functionality.

5.4.1.**2 Implement Peer-to-Peer Training*:***

Establish formal peer-to-peer ICT training programs for students to improve digital literacy, as suggested by Kozma (2008). Designate tech-savvy students as mentors to guide peers in using tools like simulations and data analysis software.

5.**4.1.3 Adopt Open-Source Resources:**

Encourage teachers to use free platforms like Open Educational Resources (OERs), Khan Academy, and PhET simulations to reduce costs, aligning with Mutula (2008) on cost-effective ICT solutions.

5.**4.2 For Teachers**

5.4.2.1 Engage in Continuous Professional Development*:*

Seek ICT training through online courses or NGO workshops, as recommended by Hennessy et al. (2010). Form school-based ICT support groups to share knowledge, enhancing skills in Biology-specific tools.

5.4.2.2 Integrate ICT Strategically:

Use ICT to target specific learning outcomes, such as virtual labs for practical skills, while balancing with traditional methods to ensure inclusivity (Tshabalala et al., 2014).

5.4.3 For the Ministry of Education

5.4.3.1 Develop a Targeted ICT Training Program:

Implement district-wide workshops on Biology-specific ICT tools, such as virtual dissections, as emphasized by Nhongo and Bizaliel (2020). Ensure training is practical and tailored to rural contexts.

5.4.3.2 Provide Policy Support for Infrastructure:

Allocate funds for low-cost devices like tablets and solar power systems, collaborating with telecommunications companies to improve internet connectivity (Mutula, 2008).

5.4.3.3 Monitor and Evaluate ICT Integration:

Establish a framework to assess ICT use in schools, ensuring equitable resource distribution, as recommended by Kozma (2008).

5.4.4 For External Partners (NGOs and Private Sector)

5.4.4.1 Fund Infrastructure and Training:

NGOs should continue donating computers and funding teacher training, while private companies can sponsor internet connectivity or refurbished devices (Mutula, 2008).

5.4.4.2 Support Community-Based Solutions:

Partner with communities to maintain ICT facilities, such as through community-managed solar systems, ensuring sustainability (Tshabalala et al., 2014).

5.4.5 For Future Research

Conduct longitudinal studies to assess the long-term impact of ICT on Biology performance and career pathways in science (Hennessy et al., 2010).

Investigate the effectiveness of specific ICT tools, for example, virtual labs vs. animations in achieving Biology outcomes.

Explore mobile-based ICT solutions, given the growing smartphone penetration in rural Zimbabwe (Nhongo and Bizaliel, 2020).

5.5 Limitations of the Study

The study faced several limitations:

5.5.1 Sample Size:

The sample (60 students, 15 teachers, 3 schools) may not fully represent Mhondoro Ngezi's diversity.

5.5.1.2 Resource Constraints:

Limited ICT access during data collection restricted observation scope, particularly in schools without functional labs.

5.5.1.3 Self-Reported Data:

Reliance on questionnaires and interviews may introduce bias, as noted by Hennessy et al. (2010).

Despite these limitations, the mixed-methods approach provided robust insights applicable to similar rural contexts.

5.6 SUMMARY

ICT integration in Biology education in Mhondoro Ngezi District enhances engagement, comprehension, and digital literacy, supporting learning outcomes. However, challenges like inadequate infrastructure, limited training, and financial constraints, as highlighted by Mutula (2008), hinder its potential. The recommendations focusing on sustainable infrastructure, teacher training, and policy support offer a roadmap for stakeholders to address these barriers. By implementing these measures, schools can harness ICT to improve Biology education, aligning with Zimbabwe's vision for quality education and global trends in educational technology (Kozma, 2008).

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APPENDIX A

INTERVIEW GIUDE FOR LEARNER

My name is Kasivila Edson, a part two student at Bindura University of Science Education. I am studying for an Honors Bachelor of Science Education Degree in Biology. In partial fulfillment of my degree program requirements I am conducting a research on assessing the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Ordinary level Biology in selected schools in Mhondoro-Ngezi District, Mashonaland West Province.. I am kindly asking you to participate in the interview which will be useful in drawing conclusions for the research. Please be assured that is for academic purposes only and the responses for the interview shall be kept confidential and as such no personal details shall be requested for in the document.

1. Can you describe how Biology is taught in your school? What methods or tools does your teacher usually use?

2. What was your first experience using ICT (like computers, projectors, or the internet) in a Biology lesson? How did you feel about it?

3. How does using ICT in Biology lessons help you understand the subject better?

4. In what ways does ICT make Biology lessons more interesting or engaging for you?

5. Do you think ICT has changed how well you perform in Biology (e.g., in classwork, tests, or practicals)? Can you explain how?

6. What challenges do you face when ICT is used in your Biology lessons?

7. Are there times when ICT didn't work well in your Biology lessons? Can you describe what happened?

8. Has using ICT in Biology helped you develop any new skills (e.g., using computers, researching online, or working in groups)? Can you share an example?

9. How do you think ICT skills learned in Biology could help you in the future (e.g., in further studies or jobs)?

10. If you could improve how ICT is used in your Biology lessons, what changes would you suggest?

11. Do you prefer Biology lessons with ICT or traditional methods (like chalkboard or textbooks)? Why?

12. Is there anything else you'd like to share about your experiences with ICT in Biology lessons?

13. Do you have any questions for me before we end?

Thank you so much for sharing your thoughts and experiences. Your input is very valuable to this study. If you have any further thoughts later, please feel free to share them with me or your teacher. Would you like me to share the findings of this study with you once it's complete?

APPENDIX B

INTERVIEW GIUDE FOR TEACHER

My name is Kasivila Edson, a part two student at Bindura University of Science Education. I am studying for an Honors Bachelor of Science Education Degree in Biology. In partial fulfillment of my degree program requirements I am conducting a research on assessing the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Ordinary level Biology in selected schools in Mhondoro-Ngezi District, Mashonaland West Province. I am kindly asking you to participate in the interview which will be useful in drawing conclusions for the research. Please be assured that is for academic purposes only and the

responses for the interview shall be kept confidential and as such no personal details shall be requested for in the document.

1. Can you describe how you typically teach Biology in your classroom? What teaching methods or tools do you use?

2. When did you first start using ICT in your Biology teaching? Can you share your initial experiences or impressions?

3. In what ways has ICT integration impacted your teaching of Biology?

4. From your perspective, how does ICT affect students' understanding and engagement in Biology lessons?

5. How do you think ICT influences the way you assess students' learning in Biology (e.g., assignments, practicals, or exams)?

6. What challenges do you face when integrating ICT into your Biology lessons?

7. Have there been instances where ICT tools did not work as expected in your lessons? Can you describe what happened and how you managed?

8. How confident do you feel using ICT tools (e.g., computers, software, or online resources) in your Biology teaching?

9. What are your personal views or attitudes toward using ICT in teaching Biology?

10. How do your colleagues' attitudes toward ICT integration compare to yours? Do you think this affects its use in your school?

11. How does the school's environment (e.g., resources, infrastructure, or support) influence your ability to use ICT in Biology teaching?

12. In the context of Mhondoro Ngezi, what unique factors (e.g., rural setting, socio-economic conditions) affect ICT use in your Biology lessons?

13. What changes or improvements would you suggest to make ICT integration more effective in teaching Biology at your school?

14. How do you envision the role of ICT in Biology education in the future, particularly in a rural setting like Mhondoro Ngezi?

15. Is there anything else you'd like to share about your experiences with ICT in teaching Biology?

16. Do you have any questions for me before we conclude?

Thank you very much for sharing your insights and experiences. Your input is invaluable to this study and will help us understand how ICT can improve Biology education. If you have any additional thoughts later, please feel free to share them with me. Would you like me to share the findings of this study with you once it's complete?

APPENDIX C

Questionnaire for Teachers

My name is Kasivila Edson, a part two student at Bindura University of Science Education. I am studying for an Honors Bachelor of Science Education Degree in Biology. In partial fulfillment of my degree program requirements I am conducting a research on assessing the impact of integrating Information Communication Technology (ICT) in enhancing teaching and learning of Ordinary level Biology in selected schools in Mhondoro-Ngezi District, Mashonaland West Province.

Instructions to Respondents

- Please answer all questions by checking the appropriate box (Yes or No) and providing additional details in the open-ended sections where requested. There are no right or wrong answers—we are interested in your personal experiences and perspectives.
- The questionnaire should take approximately 15–20 minutes to complete.
- Use the provided space for written responses to explain your answers or provide examples
- Your identity will remain anonymous and all data will be handled confidentially.
- If you have any questions, contact [Kasivila Edson /0773 833 959].
- Please return the completed questionnaire to Kasivila Edson.

1. Do you use ICT (e.g., computers, projectors, videos, or online resources) in your Biology lessons?

   [ ] Yes [ ] No

   If yes, what specific ICT tools do you use, and how often? If no, why not?

   _____

   _____

2. Did you feel prepared when you first started using ICT in your Biology lessons?

   [ ] Yes [ ] No

   Please explain your experience or feelings during your first use of ICT in teaching Biology.

   _____

   _____

3. Has ICT integration changed the way you teach Biology (e.g., lesson planning, delivery, or activities)?

   [ ] Yes [ ] No

If yes, describe how your teaching methods have changed. If no, explain why not.

_____

_____

3. Do you believe ICT helps students understand Biology concepts (e.g., cell division, ecosystems) better?

[ ] Yes [ ] No

Please provide an example of a lesson where ICT made a difference (or didn't) in student understanding.

_____

_____

_____

5. Does ICT increase student engagement or participation in your Biology lessons?

[ ] Yes [ ] No

Please describe how students react to ICT use or why you think it doesn't affect engagement.

_____

_____

_____

6. Do you face challenges when using ICT in your Biology lessons (e.g., lack of equipment, technical issues)?

[ ] Yes [ ] No

If yes, describe the main challenges. If no, explain what enables smooth ICT use.*

_____

_____

_____

7. Have you experienced technical difficulties (e.g., power outages, software issues) when using ICT in lessons?

[ ] Yes [ ] No

If yes, describe a specific instance and how you handled it. If no, what factors prevent such issues?

_____

_____

_____

8. Does your school have sufficient ICT resources (e.g., computers, internet, electricity) for teaching Biology?

[ ] Yes [ ] No

Please explain the state of ICT resources in your school and how it affects your teaching.

_____

_____

9. Do you feel confident using ICT tools (e.g., computers, software, or online platforms) in your Biology teaching?

[ ] Yes [ ] No

What factors influence your confidence (e.g., training, experience, or support)?

_____

_____

10. Have you received formal training in using ICT for teaching?

[ ] Yes [ ] No

If yes, describe the training and its usefulness. If no, what training would you find helpful?*

_____

_____

_____

11. Do you view ICT as a valuable tool for teaching Biology?

[ ] Yes [ ] No

Please explain your views on ICT's benefits or challenges in Biology teaching.

_____

12. Does the rural context of Mhondoro Ngezi (e.g., socio-economic conditions, infrastructure) affect your use of ICT in Biology lessons?

[ ] Yes [ ] No

Please describe how the rural context impacts ICT integration in your teaching.*

_____

_____

13. Does your school provide adequate support (e.g., policies, technical assistance) for using ICT in teaching?

[ ] Yes [ ] No

Please explain the type of support (or lack thereof) and its effect on ICT use.

_____

_____

14. Would additional resources or support improve your use of ICT in Biology teaching?

[ ] Yes [ ] No

If yes, what specific resources or support (e.g., more computers, training, internet) would help? If no, why not?

_____

_____

_____

15. Is there anything else you would like to share about your experiences with ICT in teaching Biology?

[ ] Yes [ ] No

_____

_____

_____

Thank you for completing this questionnaire. Your responses are invaluable to understanding how ICT impacts Biology teaching in Mhondoro Ngezi. If you have further thoughts or questions, please contact [Kasivila Edson/ 0773833959].