THE DURBAN UNIVERSITY OF TECHNOLOGY (DUT)

Analysing Factors Affecting The Wide Adoption Of ICT Among Learners in Developing Countries

By

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A dissertation submitted in fulfilment of the requirement for the Master in Information and Communications Technology Degree

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In the
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Year:2024

DECLARATION

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ACKNOWLEDGEMENTS

My sincere gratitude goes to my late parents for their strength throughout the study. In particular, I would like to extend my profound gratitude to the following people:

- My supervisor, **Dr Timothy T. Adeliyi**, whose constructive input, guidance, patience and encouragement have made this project possible from day one. His [Dr Adeliyi] dedication and insights were indispensable. Without his constructive advice, accomplishing this project would not have been successful. In all, thanks for opting for my research topic.
- My Co-supervisor, **Dr Alveen Singh**, for his guidance, experience, optimism, and support throughout this project. Thanks for being cooperative with Dr Adeliyi and me.

Furthermore, I am also at the loss of phrases to sufficiently thank my editor Ms Deborah Oluwadele for editing my work and for encouragement, inspiration, and expertise. Words alone can not express my profound gratitude to my friends Mr P.P Ntshangase, S.B Mnguni, and grandmother (Mrs P. Ngwane) for being with me during the severe and jubilation times. I appreciate your presence, understanding, and support.

Above all, an operation of this nature is impossible without the Almighty. I am thankful to the Creator of this Universe for seeing me throughout the tough journey with the swamps.

DEDICATION

I, Khanyisani I. Ndlovu hereby dedicate this dissertation to my late parents, who introduced the significance of education, belief, hard work, and optimism. We were the greatest blessing to me. I would never cherish this blessing if we never brought me to this world. I love you all!!!

To my family, may this study inspire you to become the best model of me.

ABSTRACT

The evolution of Africa from a largely neglected economy to a serious contender in the global digital and knowledge economy is hinged on enabling quality education. Education is a primer for innovation, and entrepreneurship and builds the economy through applied skills and knowledge, an undisputable foundation for recognition among the international community. Technological advances in learning and teaching have regularly featured in the African education context and huge amounts of resources are invested year after year. However, the expected improvement is mostly unrealised. This doldrum persists because the sudden and rapid insertion of technology is not well understood. This extends to a problem of stalled widespread educational ICT adoption by learners, particularly in rural secondary schools.

This study appreciates advanced ICTs as a key function to support the effective improvement and transformation of secondary school education in Africa. This study aims to identify the key factors affecting the adoption of ICT among learners in rural secondary schools. The distinctiveness of this study in a burgeoned discourse is a focus on unearthing adoption factors unique to developing African countries. A lack of understanding of these factors is presented as a knowledge gap.

A systematic literature review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. 491 relevant publications were identified from 2017 to 2023, with 84 studies selected for inclusion in the analysis after applying exclusion criteria. From these studies, 38 factors influencing ICT adoption were identified. Principal Component Analysis (PCA) was employed to reduce dimensionality and rank the factors based on their significance. The results discovered that over-digitalization of education, funding (support), health challenges (barriers), cognitive barriers, and time constraints are the top five factors that significantly affect ICT adoption among learners in rural secondary schools. These findings align with the results of the application of the Unified Theory of Acceptance and Use of Technology (UTAUT) framework which, more significantly, highlights additional challenges.

This study found additional challenges, such as the lack of ICT infrastructure which remains a major obstacle. Based on the analysis, the study proposes an extension of the UTAUT framework to better address the unique challenges faced by learners in these regions. In conclusion, the study highlights critical areas that need to be addressed to improve the wide adoption of ICT in education. By extending the UTAUT framework, the study provides a more comprehensive model that could guide policymakers, educators and Government entities in implementing effective strategies for ICT integration thus contributing to lessening the digital divide in education between Africa and the rest of the developed world.

Keywords: *Digital literacy, ICT adoption, principal component analysis, secondary schools, rural school, learners, UTAUT*

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LIST OF ABBREVIATIONS AND ACRONYMS

4IR	Fourth Industrial Revolution
5G	Fifth-Generation Wireless
ADSL	Asymmetric Digital Subscriber Lines
ATT	Attitude
AU	African Union /Actual Use
BB	Black-Board
BC	Blackboard Collaborate
BI	Behavioural Interventions
BYOD	Bring Your Own Device
CB	Cognitive Barriers
COVID-19	Coronavirus Disease
DBEd	Department of Basic Education
DER	Digital Education Revolution
Dim	Dimension
DOI	Diffusion of Innovations Theory
DUT	Durban University of Technology
EC	Exclusion Criteria
ECA	Electronic Communications Act
EDs	Electronic Devices
EE	Effort Expectancy
EP	Electric Power
ETA	Electronic Transactions Act
ETH	Ethiopia
EU	European Union
F	Factors
F.No	Factor Numbers
FBL	Facebook Live
FC	Facilitating Condition
FUN	Funding
GM	Google Meet
HC	Health Challenges
HEIs	Higher Education Institutions
IC	Inclusion Criteria
ICAI	Intelligent Computer-Assisted Instruction
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communication Technology
IDT	Innovation Diffusion Theory
IM	Instant Messaging
IoT	Internet of Things
IP	Internet Protocol
IS	Information Systems
IT	Information Technology
ITU	International Telecommunication Union
IWB	Interactive Whiteboard
KCDM	King Cetshwayo District Municipality
KENY	Kenya
KSGN	Kenya School of Government in Nairobi
MM	Motivational Model

MOOC	Massive Open Online Courses
MST	Microsoft Teams
NPOs	Non-Profitable Organizations
ODE	Over-Digitalization of Education
OLPC	One Laptop Per Child
OTPC	One Tablet Per Child
PC	Principal Components
PCA	Principal Component Analysis
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PLS-SEM	Partial Least Squares Structural Equation Modeling
PP	Papers
PPT	Microsoft PowerPoint
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PU	Perceived Usefulness (Use)
QCA	Qualitative Comparative Analysis
R	R-Studio
RSSs	Rural Secondary Schools
SA	South Africa
SD	Standardization
Sdv	Standard deviation
SI	Social Influence
SLR	Systematic Literature Review
SMEs	Small and Medium Enterprises
SSA	Sub-Saharan Africa
TA	Technology Adoption / Technology Acceptance
TAM	Technology Acceptance Model
TIM	Time
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TTF	Task-Technology Fit
UTAUT	Unified Theory of Acceptance and Use of Technology
Wi-Fi	Wireless Fidelity
XUTAUT	Extended Unified Theory of Acceptance and Use of Technology
YTL	YouTube Live

LIST OF PUBLICATIONS

Ndlovu, K., Adeliyi T., Singh, A., 2025, February. Principal Component Analysis of ICT Adoption among Students in Developing Countries in *International Congress Information and Communication Technology*. Singapore: Springer Nature Singapore.

CHAPTER 1 : INTRODUCTION AND BACKGROUND

1.1 Introduction

Information and Communication Technology (ICT) is broader than information technology (Hill and Shaw 2013). ICT encompasses information technology and different communication technologies used to transmit, exchange, and share information electronically. ICT entails telecommunications infrastructure, internet services, mobile technologies, digital media, and collaboration tools. It also encompasses broader applications and services beyond traditional information technology, including email, instant messaging, social media, video conferencing, and cloud computing. This is affirmed by Jha *et al.* (2023), who described ICT as an umbrella term encompassing communication devices such as computers, mobile phones, radios, televisions, and network hardware, as well as services like audio and video calls, text, and multimedia messages. Orhani *et al.* (2023) also defined ICT as a tool that learners and teachers significantly use for online education.

In contrast, Information Technology (IT) usually focuses on managing, processing, data storage, and transmitting digital information. It encompasses hardware, software, networks, databases, and other technologies used to manage and manipulate data. Furthermore, IT encompasses various specialized areas, including computer hardware, software development, network administration, cybersecurity, database management, and technical support. Ahmad and Daud (2016); Odubiyi, Aigbavboa and Thwala (2019) described IT as a tool encompassing soft and hard programming skills. Information technology professionals are typically responsible for designing, implementing, and maintaining computer systems, networks, and software applications to support organizational needs.

While IT focuses on the technicality of managing and processing digital information, ICT encompasses technologies that facilitate the exchange of information—making IT a subset of ICT. Hence, the focus of this study is ICT. In the ICT domain, rapid technological advancements since the early 1980s have created opportunities for new entrants (Mesaros *et al.* 2020). These technologies were gradually distributed across different countries, reflecting the increasing export rate of trade in ICT products in the mid-1990s (Kiriyama 2011). The adoption and use of ICT improve the competitiveness of organizational tasks (Ogundile *et al.* 2019).

In several studies, the implementation of Information and Communication Technology in schools has been shown to transform education in various ways. It enhances learning experiences through collaborative and blended learning (Sahija and Cruz 2022; Anastasopoulou *et al.* 2024). This improved learning experience is made possible by utilising ICT tools such as Microsoft Teams (MST), Google Workspace, and other educational platforms like Moodle and Blackboard, among

others. According to Bakkar and Kaul (2023); Anastasopoulou *et al.* (2024) the adoption of ICT will prepare learners for the future and establish a solid foundation for the Education 5.0 era.

Education 5.0 is an emerging concept that builds on previous educational paradigms (Education 1.0 to 4.0) by emphasizing human-centred, technology-enhanced, and purpose-driven learning. It moves beyond the automation and digitalization focus of Education 4.0 to prioritize human values, sustainability, and well-being in education (Alharbi 2023; Babu 2024). Adopting ICT in developing countries worldwide has resulted in varying perspectives on approaching this phenomenon from a rural school standpoint (Mangione 2024). There needs to be a clear comprehension of how well rural secondary schools succeed in adopting ICT in the teaching and learning process. Yurtseven Avci, O'Dwyer and Lawson (2019) recommended that schools should consider their unique context and challenges when integrating technology into the teaching and learning process. As these require context-specific and friendly solutions. Moreover, Munje and Jita (2020) have found that schools often fail to utilize ICT tools in teaching and learning, leading to underutilising existing resources and negative educational implications. These factors have severe and different outputs in the academic domain.

In exploring the impact of the lack of ICT resources on teaching and learning in selected South African primary schools, Munje and Jita (2020) reported different challenges. For example, schools do not use ICT infrastructure in the teaching and learning process and sometimes underuse digital resources at primary schools. Munje and Jita (2020) also claimed that the South African Department of Basic Education (DBEd) considers individual school contexts when allocating ICT resources to address the existing challenges. The pursuit of these challenges comprises the lack of encouragement to form partnerships with communities to ensure the safety of digital devices in schools. Moreover, Tadesse and Muluye (2020) stated that teachers face challenges in technology adoption, exacerbated by inadequate ICT infrastructure. Khan (2020) argued that using ICT in teaching and learning can potentially improve learner achievement. This is especially important in areas with low socioeconomic status where learner achievement is more likely to fall below expectations. This study emphasizes the need for empirical research to evaluate the impact of inadequate ICT Infrastructure on the teaching and learning process, particularly in developing countries with low socioeconomic status. This study thus focuses on the analysis of factors affecting the widespread adoption of ICT among rural secondary learners in developing countries.

Besides, the lack of ICT infrastructure emphasizes the digital divide among learners in developing and developed countries. The digital divide has become a crucial economic and social issue that has gained significant attention recently. This term refers to the inequalities in access to technology and the internet based on social factors, education, and society (Farooqi, Khalid and Khan 2022). These disparities affect educational systems, households, individuals, and businesses worldwide. The digital divide is an economic and social issue that has gained significant interest recently. The term 'global digital divide' refers to the disparity in access to digital resources between developed and underdeveloped countries.

In contrast, at the national level, it is called the urban-rural divide (Aruleba and Jere 2022). This is because information flow is higher in urban areas than in rural ones in developing countries (Salemink, Strijker and Bosworth 2017). The prime issue of internet and broadband infrastructures causes this. In exploring accessibility and connectivity in rural communities, Velaga *et al.* (2012) reported significant reasons for the digital divide as rural schools are pressured to keep up with the pace of digital connectivity; for example, internet and broadband infrastructures are difficult to reach in rural areas. This study identifies comprehensive factors creating disparities among rural secondary learners in developing countries.

Bingimlas (2009); Oye, Iahad and Rahim (2014) reported that time and staff support are the major factors affecting the widespread adoption of ICT. Schools give teachers little time to interact with technology (Ertmer 1999); therefore, the little period allotted to teachers to arrange the curriculum (Buda 2020) is devastating, as teachers cannot plan the study's curriculum accordingly. Despite time being seen as a significant challenge, the cognitive barrier is an internal factor that affects the widespread adoption of ICT (Buda 2020). According to Seeman and Lewis (2019), cognitive barriers in ICT involve challenges faced by learners with mental disabilities affecting their ability to access technology. However, Dirks *et al.* (2020) argue in their studies that digital technologies can help to overcome these cognitive barriers in ICT.

Due to the lack of ICT devices in developing countries (Ferri, Grifoni and Guzzo 2020; Joseph 2021), which is compounded by insufficient funding (Prasojo *et al.* 2019; Rana and Rana 2020; Nikolopoulou 2021). Therefore, addressing these challenges by distributing ICT devices would enable learners to engage more in training and continuous practice (Joseph 2021). In addition, schools should be funded, and the Department of Basic Education should always make a proper investment in ICT devices (Mulauzi, Walubita and Pumulo 2019; Joseph 2021). As a result of this, providing these essential devices could alleviate and rectify the difficulties faced in the teaching and learning process, particularly in remote rural areas with limited access to technology (Mulauzi, Walubita and Pumulo 2019; Hasin and Nasir 2021; Joseph 2021).

To motivate teachers and learners to adopt ICT in rural schools, the Department of Basic Education, policymakers, the private domain, and so on must release incentives that could infuse teachers and learners into the educational domain, with sufficient funds distributed in the ICT domain, specifically in rural schools. Previous studies reported limited budgets (Karsenti and Charlin 2008), and limited educational domains. Funding is one of the exogenous variables reported in PCA and the over-digitalization of education. These findings are consistent with a study by Nikolopoulou and Gialamas (2016), who reported lack of funding as the most significant barrier to ICT use in high schools. Notwithstanding, Krubu and Osawaru (2011) ‘inadequate funding’ is the greatest prime challenge against the successful use of information and communications technology in Nigerian University libraries. Moreover, inadequate funding was advocated.

The transformation of traditional learning into blended learning can introduce innovativeness in educational settings. Education has been re-engineered to adapt to the changing demands of modern life. This is validated during the era of the Coronavirus Disease (COVID-19) pandemic; a vast number of countries have institutionalized the application of digitalization of scholars nationwide. This transformation also impacted higher education institutions (HEIs); Kopp, Gröblinger and Adams (2019) digital transformation impacted the HEIs. Moreover, the cost of digitalization affects the budget (financial issue). The cost of digitalization could also impact the core growth of small and medium enterprises (SMEs).

A study by Kwarteng *et al.* (2022) identified that digitalization is a prime core growth of SMEs. By not considering the cost of over-digitalization of education, the enrichment of the educational domain could be degraded. Over-digitalization of the educational sector ameliorates education and engineering communication groups, such as study groups, chat groups, and questions and answers on social platforms. According to Haleem *et al.* (2022), technological advancements have simplified student life. Instead of pen and paper, learners use various software and tools to create presentations and projects. These innovations simplify learning into a short format that meets the teaching and learning process by not being time-consuming.

Hence, this study reviews extensive technology acceptance literature that can enrich scientific knowledge on factors affecting the widespread adoption of ICT among rural secondary learners in developing countries. Researchers worldwide have extensively conducted studies on technology acceptance for over two decades. Many studies were conducted applying theories and models (for example, technology acceptance, diffusion of innovation theory, task-technology fit, and unified theory of acceptance and use of technology) models in various contexts to obtain the aim and objectives of this study with different outcomes. (Davis, Bagozzi and Warshaw 1989) developed the technology acceptance model to predict the use and acceptance of information systems (IS) or IT. This model is built upon the Theory of Reasoned Action (TRA) of (Fishbein and Ajzen 1975), which indicates that perceived usefulness (PU) and perceived ease of use (PEOU) are the prime challenges of attitude (ATT) in connection with information systems (IS) or information technology (IT), which in turn predicts behavioural interventions (BI) and actual use (AU). This study refers to technology adoption connected with social influences, effort expectancy, performance expectancy, facilitating conditions, over-digitalization of education, funding, health challenges (barrier), cognitive barrier, and time.

So, with the unavailability of IS/IT tools, it is not easy to test the adoption of ICT among learners in developing countries in this study. Bariu (2020) reported that many schools in Kenya have the lowest level of investment in ICT infrastructure due to excessive hardware and software. This is consistent with the fact that access to higher education in Africa is limited despite its crucial role in the success of students and countries. Moreover, the use of ICT infrastructure has significantly

developed ICT skills and competencies, so it is sagacious to encourage all stakeholders to address the recurring challenges of ICT infrastructure. This study could not employ TTF; instead, it uses the UTAUT model with new PCA results to form an extended model.

Discussing the diffusion of innovations theory (DOI) developed by Rogers (2003) is a great honour. Previous researchers have discussed DOI in terms of using, integrating, and adopting IS/IT. In exploring 'reviewing factors preventing university academics from embracing new ICT', integrating ICT into learning and processes requires an academic to change the strategies in which academic is delivered (Goh and Sigala 2020). The new delivery of change in academics brings a new format of teaching and learning that obliges learners to be agile. Agile is a way of working and rapid mindset change to absorb new ideas.

In exploring the potential factors influencing students' behavioural intention to use the e-learning system', Al-Rahmi *et al.* (2019) find that all six innovation traits affect students' e-learning systems' behavioural intention, for example 'observability, trialability, perceived compatibility, complexity, and perceived enjoyment on the perceived ease of use is noteworthy'. It is not arguable that antecedents of the Technology Acceptance Model (TAM) are the greatest factors inhibiting the adoption of ICT. This is referenced by Kasilingam (2020), a conducted study probing the 'understanding of the use of smartphone chatbots for shopping' indicated that ATT to use chatbot was only influenced by perceived use, perceived ease of use, perceived enjoyment, price consciousness, perceived risk, and personal innovativeness. Even so, trust in information systems only affects BI's use of chatbots. Many users fail to trust online systems because of fraud. So, it is the best technique to develop systems with robust security. This could motivate learners to adopt ICT in the educational domain. A study by Rana and Rana (2020) discussed the lack of motivation to use available resources as a prime factor hampering the adoption of ICT in Nepal. Furthermore, Almaiah, Alamri and Al-Rahmi (2019) results reported that perceived information quality, compatibility, trust, awareness, availability of resources, self-efficacy, and security are the primary motivators of learners' acceptance of mobile learning systems. Based on this, all stakeholders, policy-makers, educational branches, and private and public domains require a well-focused on Almaiah, Alamri and Al-Rahmi (2019) results to motivate school learners.

1.2 Research problem statement

In the modern era, Information and Communication Technology (ICT) has become a mouth-watering phrase and a pillar of the educational system. Even so, ICT adoption remains low in developing countries, and a lack of ICT network infrastructure, computers, internet access, radios, and televisions (Tadesse and Muluye 2020) wreak havoc on the use, integration, and adoption of ICT in remote rural areas. According to Spiteri and Chang Rundgren (2020), 'digital technology' is widely accessible in schools; however, the results from extant literature indicate that it is ineffective for learners. Moreover, four influential factors were identified as the source of the ineffectiveness of 'digital technology' (teachers' knowledge, skills, attitude, and culture) (Spiteri

and Chang Rundgren 2020). The growth of the ICT context in the modern age further disrupts the process of pedagogy in schools. The reason for that is 'many developing countries in Africa are living in a world of technological deficiency' (Ongwenyi, Mumo and Mueni 2023).

The integration and adoption of Information and Communication Technology in educational settings of developing countries face multifaceted challenges, as expounded by recent studies. Aruleba and Jere (2022) delve into the digital transformation hurdles within rural South African regions, pinpointing socio-economic conditions, technological barriers, and political issues as primary deterrents to technology's widespread acceptance and use. Complementing this viewpoint, Bolaji and Onikoyi (2024) identify additional obstacles in the context of Lagos, Nigeria's secondary schools, including the remediation needs of ICT infrastructure, unreliable electricity supply, high costs associated with digital devices, inadequate policy frameworks, substandard network connectivity, and a general scarcity of ICT competencies. A critical aspect that aggravates the difficulty of ICT adoption is the necessity for specialized IT expertise, not only in the deployment but also in the effective integration and utilization of ICT resources in educational processes (Ali *et al.* 2024; Munandar and Cahyana 2024). Another significant barrier is the prevalent 'technology fear' and resistance to change among stakeholders, which stymies progress even when opportunities for advancement are available (Aruleba and Jere 2022; Kruger and Steyn 2024).

These findings underscore a persistent gap in technology adoption between developing and developed nations, where the latter enjoy a more fruitful engagement with technology. Given these enduring challenges, there is a clear and pressing need for further research to uncover additional factors that inhibit the broad adoption of ICT in education within developing countries. This research gap signifies the discrepancy in technology adoption rates. It highlights the urgent requirement for targeted studies to bridge the divide in technology utilization, ensuring that the benefits of digital education are accessible across diverse geographic and socio-economic landscapes. Despite the Electronic Transaction Act of 2005 and previous studies addressing the ICT problems in recent years, there seems to be no effective solution in solving the ongoing problem. In response to ICT problems, this study will attempt to address the overall contribution of ICT problems in rural secondary schools by developing an approved framework of the greatest factors to mitigate hindrance factors affecting the contribution of ICT in the educational domain. The modernization framework will report the major factors of technology adoption. This way, we collected adequate information to solve the research problem and identify the research gap among rural learners.

1.3 Aim and Objectives

This study aims to identify factors that influence the widespread adoption of ICT among rural secondary learners in developing countries. The following objectives were defined to achieve this aim:

i. To comprehensively review and identify factors that influence the widespread adoption of ICT among rural secondary schools from the literature.
ii. To rank the identified factors based on their importance using Principal Component Analysis.
iii. To develop a framework to aid the widespread adoption of ICT among rural secondary schools.
iv. To perform a comparative analysis of the new framework's construct against the state-of-the-art ICT adoption framework.

1.4 Research questions

The following research questions are designed to address the objectives of the study:

RQ1. What factors affect the wide adoption of ICT among rural secondary learners in developing countries?
RQ2. How does Principal Component Analysis assist in identifying the key factors in ICT adoption?
RQ3. How can the identified factors be addressed within the new model to improve ICT adoption in rural secondary school learners in developing countries?
RQ4. How does the new ICT adoption model compare to the existing model in terms of addressing the influencing factors in rural secondary school learners in developing countries?

1.5 Significance of the study

In this study, a study framework was developed and analysed to assist policymakers and the Department of Basic Education (DBEd) in solving the adoption of Information and Communication Technology among rural secondary school learners dwelling in developing countries. So, the study framework included prime challenges influencing the widespread adoption of ICT in developing countries. The significance of this study framework is as follows:

(i) The significance of this study is to assist policymakers and the Department of Basic Education in improving the adoption of ICT in rural secondary schools in developing countries.
(ii) The widespread adoption of ICT can help to narrow the gap in rural secondary schools in developing countries compared to the schools in developed countries, which can inform the DBEd and policymakers about the predominant factors affecting this issue. Based on the challenges highlighted in this study, it can be easier for DBEd to distribute missing devices required to embrace ICT in rural secondary schools in developing countries.

(iii) Investigating these challenges can create positive and negative influences on adopting ICT in rural schools. For example can motivate, collaborate, enhance learning, and share information and can be destructive, mislead learners to follow unreliable sources, and evolve cyberbullying among learners and many more.

(iv) This study can prepare rural learners for the future and achieve a rigid foundation for the coming technology Education 5.0 era.

1.6 Limitation of the study

This study is limited to only developing countries. The reason for that, this study is conducted in South Africa (SA) reported as a developing country in the Sub-Saharan Africa (SSA) region. These regions are among the countries experiencing difficulties in terms of ICT adoption, especially in rural areas where there is a technology deficiency. Consequently, because of this limitation, the findings of this study could not unpack more influencing factors in developed countries as this study was focused on rural secondary school learners in developing countries.

1.6 Structure of the thesis

This study is divided into five chapters.

A summary of this study regarding five chapters is highlighted here. The first two chapters present the introduction, and literature review, while the preceding two chapters present the methodology and a detailed discussion of the study. Finally, the last chapter introduces the summary of the thesis including the future works.

Chapter One: Introduction and Background
The first chapter introduces the background of this study and reports on the challenges related to the ICT adoption process. Furthermore, the chapter presents the aim, research objectives, and research questions to meet the study's requirements.

Chapter Two: Literature Review

Chapter Two presents a detailed potent information related to the adoption of Information and Communication Technology (ICT). Furthermore, discusses critical challenges influencing the adoption of ICT from the extant literature presentation of different models applied in previous studies in the use and adoption of ICT.

Chapter Three: Research Methodology

The third chapter presents the measure steps taken in the design of a study framework. The study methodology framework was developed with new features supporting the research problem. The data collection guidelines undertaken during the study are identified in Chapter Three. The comparison of an extant framework and a new framework explains all relevant considerations.

Chapter Four: Presentation of results and discussion
Chapter Four presents the results and discussion of the study. The results analysis of the dimensions was measured in the diagram with a scree plot. In the proceeding sections, the communality table, and principal component analysis. The study framework was introduced in this chapter with new constructs (funding, over-digitalization of education, health challenges, cognitive barriers, and time). Furthermore, external and internal variables of ICT adoption, the benefits of extended framework, justification of choosing the UTAUT instead of TAM, and TTF, and summarize Chapter Four.

Chapter Five: Summary, conclusion, and implications of the study
In Chapter Five, the summary of this study is made, rewording the study conclusion, contribution and future works needed are highlighted for the improvement of ICT adoption in developing countries.

1.7 Chapter Summary

This chapter has reviewed the background of the study by positioning it between the area of challenges influencing the widespread adoption of ICT supported by the different challenges investigated in the extant literature. The aims, objectives, significance, and limitations of this study were highlighted. A comprehensive extensive review of literature that focuses on the challenges of ICT adoption is expounded in the following Chapter Two.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter presents an extensive overview of closely related studies to improve information and communication technology adoption in rural secondary schools in developing countries. This is a critical step in the research process to answer this study's research questions. This chapter is divided into eight different sections as follows:

The first section presents ICT adoption among learners in developing countries, while the second section introduces the role of access to ICT infrastructure. Section three discusses the benefits and characteristics of ICT adoption. Section four presents ICT adoption theories and different types of models, as well as the benefits and barriers of each model. Section five describes the significant role of ICT in the classroom. Section six unpacks the influence of both schoolteachers and parents on their learners, and section seven presents factors of ICT adoption among learners in rural secondary schools. Finally, section eight presents the chapter summary.

The digitalization of education through the use of the Internet is the predominant approach in the teaching and learning process. Previous studies show that Nigerian learners were dejected by the introduction of virtual classes during the lockdown period, stating that they would not pursue

online studies after the pandemic due to the poor internet and rare electric power (Egielewa *et al.* 2022). The study concluded that Nigerian students in higher institutions accepted the over-digitalization of education but preferred a face-to-face learning approach, and this behaviour puts them into a 'Laggards' group of the diffusion of innovation theory (DOI) model; this group of people usually slowly to accept innovation (Egielewa *et al.* 2022), not willing to adopt new changes, doubtful of change (Sartipi 2020), and require display statistics and authentication to be convinced.

During the pandemic, the education system was transferred from face-to-face to hybrid learning to ensure that education was not interrupted. This created many challenges in low- and middle-income countries. In online classes, the teacher works from home with devices connected to the internet, using communication platforms such as Microsoft Teams and Zoom. Otterborn, Schönborn and Hultén (2018) revealed a high degree of preschool learners engaged with tablets. With the progressive integration and use of technology in schools, teachers use interactive whiteboards, projectors, and cloud storage to store data. Evidence shows that the traditional learning approach is outdated now; Australian institutions offer virtual classes to support students outside the campus due to distance constraints (Chen, Dobinson and Kent 2020). To ensure that virtual classes are effective, the 'Blackboard Collaborate' tool, which includes 'video conference, text, voice chat, and interactive whiteboard' (IWB), 'Blackboard Collaborate' (BC) is an effective e-learning tool (Chen, Dobinson and Kent 2020). Moreover, the findings show that using the BC tool motivates learners, assists learners in sharing knowledge, facilitates time, and improves relationships among learners; also, negative impacts are identified, such as technical issues (Chen, Dobinson and Kent 2020). The actual use of the BC tool has resulted in effective results; for example, it motivates learners, helps learners to share information, manages time consumption, and improves friendships among learners (Chen, Dobinson and Kent 2020).

Smartphones are the most widely used technology devices since they are easy to install and can be used for prominent applications, such as search engines, WhatsApp, Adobe Reader, and Microsoft Office, and are affordable tools; hence, teachers prefer smartphones for outside school communication (Iqbal and Bhatti (2020). However, challenges for smartphone use in Sub-Saharan Africa include financial constraints (Demirgüç-Kunt *et al.* 2020; Pal *et al.* 2020), expensive data costs and smartphones (Chaputula and Mutula 2018; Chisango *et al.* 2020; Aruleba and Jere 2022; Matli and Phurutsi 2023). These affect learners' ability to use smartphones to access learning material. Yermack (2017); Iqbal and Bhatti (2020) However, as the volume of smartphone users increases, the cost decreases in developing countries (Yermack (2017) Iqbal and Bhatti (2020)). Iqbal, Khan and Malik (2017) admit that in developing countries, there is greater adoption of smartphones by users. Notably, though, purchasing expensive equipment does not guarantee the quality of the mechanism (Giussani *et al.* 2022).

The following section discusses ICT adoption in developing countries, consulting recent studies that have set out to understand why ICT adoption is challenging, specifically in rural secondary schools. Various factors are derived from multiple extant literature from 2017 to date.

2.2 ICT adoption in developing countries

Information and communication technology increases access to education, improves the quality of education, and enhances the ability to communicate with different people. Previous studies reported that schools often have 'low investment' in ICT infrastructure (Bariu 2020) caused by excessive hardware, software, and other ICT prerequisite tools. The use of ICT infrastructure necessitates the development of new skills for teachers and learners, policymakers, and other stakeholders. They must also narrow the gap between ICT infrastructure and poor networks in developing countries. Jamil (2021) highlighted the effect of ICT in some key areas in developing countries. Based on Jamil (2021) findings, there are different challenges affecting Ubiquitous Technology (Utech) in various sectors, including educational inequalities, religion, culture, gender, and income; it also reveals policy-related challenges such as poor policy implementation and enrichment, lack of distributing enough funding at federal and state affect the digitalization. A study by Rana and Rana (2020); Tadesse and Muluye (2020); Chisango and Marongwe (2021) finds poor implementation of ICT policy in the educational sector. Seifu (2020) identified modest ICT skills and competency among teachers in rural schools and electricity issues (Seifu 2020; Bolaji and Onikoyi 2024). This implies that schoolteachers need to have enough time for assessment and planning, especially since Seifu (2020) reported that the lack of sufficient time acts as a career barrier to the integration of ICT. Buda (2020) affirmed that the period allotted to schoolteachers to plan the curriculum is devastating, as schoolteachers could not plan the curriculum of the study accordingly.

The concept of modern education introduced innovations in the educational system. Joseph (2021) states that ICT is vital in terms of improving the teaching and learning process in secondary schools, even though challenges are in persistence. Education needs an agile mind to adapt to advanced technology, modern ICT infrastructure, 'digital natives', collaboration, stable network (Wi-Fi), computer labs, ICT experts for technical support, and teachers with a clear understanding of Information Technology (Hatherly 2009; Namdev 2012; Petkovics and Petkovics 2014; Bushuyev *et al.* 2021). Despite these requirements, developing countries are lagging in using advanced technology. According to Kozlova and Pikhart (2021), collaborative learning is an effective way to enhance the learning experience by bringing it into a social context. Collaboration has advantages in the teaching and learning context. In this approach, knowledge is constructed by cooperation and sharing among learners. One of the significant advantages of collaborative learning is that it helps learners acquire skills not directly related to the subject itself, such as communication and collaboration skills.

Through initiative and innovation in ICT, learners can learn, adapt, transfer data, collaborate, and communicate virtually. According to Tembo and Mwale (2019), there is a serious shortage of relevant literature in developing countries, and a shortage of ICT skills for schoolteachers and learners is the principal challenge for ICT adoption, integration, and usability. Furthermore, a study by Champa, Rochsantiningsih and Kristiana (2019); Rahiem (2020); Seifu (2020) identified that

teachers had limited ICT skills. This factor has gained attention during the pandemic in developing countries. Even so, it has been reported that teachers continuously lack ICT skills and competency. They are willing to attend supplementary training (Henderson 2020), but this could not succeed due to Rahiem (2020) lack of ICT infrastructure, unavailable networks (Wi-Fi), and modes of ICT skills. Moreover, there are more challenges to teachers 'acceptance and adoption of ICT' (Henderson 2020). Rural areas have lower incomes than urban areas, so to narrow this gap, rural areas should receive additional support (funding) from different stakeholders, such as the government, the private sector, and non-profit organisations (NPOs), to support ICT. In terms of support, a study by Almaiah, Al-Khasawneh and Althunibat (2020) reported that three deterrent factors impeeding eLearning are change of management, eLearning technical problems, and lack of financial support in an exploration of factors influencing eLearning systems. A systematic review conducted by Turgut and Aslan (2021) also reported the integration of ICT is often affected by the unavailability of technical support in schools.

Administrators have a significant effect on the integration of ICT (Turgut and Aslan 2021). With different perspectives from different studies, it is reported that financial issues are not yet resolved in the ICT sector; this is confirmed by Joshi, Vinay and Bhaskar (2021) in a conducted study of the 'Impact of coronavirus pandemic on the Indian education sector', the findings show that there is a slight fund budget for ICT in schooling. Moreover, schools do not have enough support, such as a budget for buying advanced devices and technical support (Joshi, Vinay and Bhaskar 2021). In today's ICT, a study by Bolaji and Onikoyi (2024) recommended that to solve this progressive problem, the government needs to expand the funding in higher education and come out with different recommendations to support education with funding. Bolaji and Onikoyi (2024) acknowledged that the government should improve 'funds' for ICT in the education sector.

2.3 The role of access to ICT infrastructure

ICT infrastructure plays a significant role in terms of access staff to learners; there are non-identical factors that lead to this lack of access, which include limited access to digital devices, for example, lack of ICT devices (computers or laptops, cell phones, and tablets), and lack of internet access in rural areas of developing countries like South Africa (SA), Kenya (KENY) and Ethiopia (ETH) and so on. Rural areas can improve cost efficiency by reducing distribution and telecommunication costs while serving low-income households, boosting the economy of small and medium businesses in rural communities. Thus, limited access to ICT infrastructure affects the widespread adoption of ICT in rural learners and affects the freedom of learning among learners.

Limited access to ubiquitous ICT infrastructure such as smartphones for learners (Aruleba and Jere 2022), electricity interruption (Mihai 2017; Bester *et al.* 2021), expensive data costs, and smartphones (Chaputula and Mutula 2018; Chisango *et al.* 2020; Aruleba and Jere 2022; Matli and Phurutsi 2023) affect some learners' ability to embrace ICT and access learning material. Often,

learners prefer online learning to traditional learning, where the teacher must spend more hours reading textbooks in front of the learners (Bester *et al.* 2021). Information and Communication Technology can add more to the quality of education, but the unavailability and insufficiency of ICT infrastructure (Mhlana, Chipangura and Twinomurinzi 2021; Mahlo and Waghid 2022; Ssenyonga *et al.* 2022; Sulistiyo *et al.* 2022; Teye and Duah 2022; Van Greunen and Fosu 2022; Gamit 2023; Matli and Phurutsi 2023; Shala and Grajcevci 2023; Zenda and Dlamini 2023) hamper the digitalization of education, specifically in developing regions. 'ICT used in secondary school education has gained acceptance and recognition as the main enabler and driving force towards human knowledge development' (Pima 2019).

These resources form part of ICT and need to be available anytime. They can act as catalysts for enabling technology to solve educational challenges. In less developed countries like Tanzania, approximately 91% of learners and teachers buy at least one device to connect to the internet (Pima 2019). This is in line with a study by Chigona and Mooketsi (2011); Chisango *et al.* (2020), where only 25 desktop computers are available to be used by 700 learners in rural schools, and these desktop computers are expected to be used by learners over 1 000 in one computer laboratory (Chigona and Mooketsi 2011). This indicates inadequate ICT infrastructure in rural schools and the perpetuation of poor educational results in developing countries. With limited physical access to ICT infrastructure in Emalahleni and Intshika-Yethu, respondents reported in a previous study conducted by Chisango and Lesame (2017) that there is one center in the municipality located in a town that has only ten computers required to support and service 200 villages. This shows that learners and schoolteachers are not embracing ICT for quality education. Information and Communication Technology can be used as a tool to improve the quality (Hossain, Hashmi and Mezbah-ul-Islam 2019). In addition, ICT is regarded as a vital mobile vehicle that can drive education nationwide. This drive could be ascertained with the availability and accessibility of internet access.

2.3.1 Internet access

The lack of internet access (Coopasami, Knight and Pete 2017; Barnard-Ashton *et al.* 2018; Harerimana and Mtshali 2018; Madida, Naidoo and Rugbeer 2019; Chisango *et al.* 2020) and the high cost of data bundles and technology devices (Bester *et al.* 2021) limit the adoption of ICT in rural schools. Matli and Phurutsi (2023) investigated Learners concerns about Online Remote Learning during the Coronavirus Disease (COVID-19) pandemic in the Fourth Industrial Revolution (4IR) digital society; respondents reported that data cost and poor network connectivity in impoverished areas were the major challenges during the COVID-19 pandemic. Weak and/or poor internet access affects the adoption of ICT, often in less developed countries. The high cost of internet access causes this (Matli and Phurutsi 2023; Ngodu, Ndibalema and William 2024), and technological devices such as smartphones, laptops, and tablets (Bester *et al.* 2021). Internet connection requires a basic understanding of networks, the supply and launch of projects, training, ICT skills, and enough time for teachers to participate in training and support. These could reduce

the suffering of teachers and learners in the integration, adoption, and use of ICT technologies in rural secondary schools in developing countries.

Internet access plays a significant role in enhancing the quality of education. Often, internet access is a driver of sharing information in any industry, for example, education, health, agriculture, hospitality, marketing, engineering, communications, banking, and many more. Access to the Internet in education has significantly transformed schooling regarding communication, data storage, and learning. Even though extant literature reported internet access as the major barrier to the adoption of technology in rural schools. Based on this, a study by Tamah, Triwidayati and Utami (2020); Basar *et al.* (2021) find internet access as the constraining factor responsible for the limitations of technology adoption in rural secondary schools.

2.3.2 Electric Power (EP)

The lack of electricity immensely impacts ICT integration and adoption because ICT infrastructure needs electric power to operate. Prior desktop computers had large cathode ray tube monitors; each desktop computer required 150-200 (W) watts of power (ICTWorks 2013). Electricity and network challenges are progressive in Ghana (Adarkwah 2021). This challenge also has a gigantic impact in the SSA regions like Nigeria (57%), Ethiopia (50%), and the Democratic Republic of Congo (19%), leaving approximately 173 million people without access to electricity in these countries (Rodriguez-Segura 2020).

Although embracing ICT in education, healthcare, agriculture, and other industries is crucial, developing countries must develop new strategies to solve electricity challenges (Al-Ansi, Garad and Al-Ansi 2021). The promotion of blended learning is based on the availability of ICT infrastructure, electricity and internet access. A study by Mabeya (2020); Adarkwah (2021); Al-Ansi, Garad and Al-Ansi (2021) finds these challenges in electricity and internet access as the prominent factors that affected ICT-based learning during the pandemic in developing countries. 'ICT-based learning' is a learning system that applies ICT to assist, change, and reinforce knowledge (Al-Ansi, Garad and Al-Ansi 2021).

With increased ICT utilisation in education, electricity remains the progressive barrier in rural areas where households receive less income (Sadorsky 2012). Information and communication technology growth is higher than the income rate of the household, and the effect of electricity demand is higher than the income rate on electricity demand. This is consistent with a study by Jamil (2021), which found that the technology adoption vision has not yet been implemented in developing countries that receive low incomes. A few years back, low-income households were denied electricity meters in Soweto, South Africa (Kambule *et al.* 2019) due to the high cost, lack of quality consultation, high degree of electricity usage, and unreachable political promises. Low-income countries find it difficult to use electricity due to the high cost of electricity and load-shedding. The cost of electricity is a huge barrier to ICT adoption in developing countries (ICTWorks 2013). Moreover, more than 80% of higher institution students are based in far-flung rural areas without electricity access in Ethiopia (Mengistie 2020). Similarly, almost 40% of

learners live in rural areas (Basar *et al.* 2021), with rare electricity supply (Bakibinga-Gaswaga *et al.* 2020; Kebwaro, Kevogo and Mwebi 2024).

Despite the massive cost and poor supply of electricity in developing nations, devastating load-shedding (power outages) continues slowing down technology adoption in rural and urban areas. A study by Tigere and Netshitangani (2022) finds that 'electrical power interruptions due to the load shedding' have a massive impact on the integration of ICT in the rural secondary schools of KwaZulu-Natal, South Africa. According to Adarkwah (2021), power outages are a deterrent factor in accessing online learning in Ghana. In another study conducted by Ojo and Onwuegbuzie (2020), the participant (student) reported that "There was no electricity for the past twelve days because of this. Electricity cuts cause serious predicaments; some departments have reserved generators, and some do not. This cut takes a long time, forcing educators to not use applications and to manually prepare documents. This way, the manual is time-consuming and unsuccessful most of the time (Al-Ansi, Garad and Al-Ansi 2021).
This study implies that policies are designed to close the gap of inequalities between low- and high-income rates between developing and developed countries. Furthermore, policymakers can resolve the issue of electric power by seeking private and international sectors to finance developing countries with essential resources to improve power outages. Finally, the high cost of electricity needs special attention with the high cost of electronic devices discussed in extant literature.

2.3.3 The high cost of electronic devices

The trend and advent of ICT in education are forcing teachers and learners to purchase ICT devices and stay connected with technology. Despite the trend, that ICT tools are unaffordable for learners in rural schools, the unaffordability of purchasing ICT devices is a known crisis in rural communities. This is authenticated by Mengistie (2020); more than 80% of learners in Ethiopia do not have access to laptops, smartphones, and desktop computers due to the high cost. High costs are one of the other factors considered when purchasing ICT devices (Keane and Keane 2020).

A study by Bariu (2020); Mabeya (2020); Rahiem (2020); Al-Ansi, Garad and Al-Ansi (2021); Molla and Seyoum (2022); Kebwaro, Kevogo and Mwebi (2024) find that the high cost of ICT devices, software, hardware, and other technology resources is a high-ranked challenge to accessing ICT-based learning, this challenge was highly identified during the pandemic era, it might take time to proceed from face to face approach to modern teaching and learning process in rural schools due to the external factors manipulating schools, for example, inability to purchase expensive digital devices (Rana, Greenwood and Fox-Turnbull 2020). This is consistent with a study conducted by Mengistie (2020), which found that the execution of online learning is an impediment factor in Ethiopia because of the high cost of the internet. Ethiopia is the world's leading expensive internet (Mengistie 2020). To remedy this high cost of ICT infrastructure, the school management can ask the government to replace the high-cost laptops with mobile devices such as tablets (Adarkwah 2021). Another critical challenge is the data cost (Rahiem 2020) when

embracing technology. To overcome the high costs of internet access, it is advisable to reduce the cost of the internet by making websites free of charge (Azhari and Fajri 2022).

The extant literature has reported that the high cost of technology devices is progressive. Accordingly, most of the time, learners are not able to afford the purchase of laptops and smartphones; by contrast, schools are not fully equipped to underpin learners needs, the high cost of the network (Wi-Fi), internet access, and high-cost of electronic devices is not affordable for learners (Al-Ansi, Garad and Al-Ansi 2021). A study by Arthur-Nyarko, Agyei and Armah (2020) implied that policymakers could apply the Bring Your Own Device **(**BYOD) approach to support distance learning materials in measuring student readiness and challenges. Furthermore, Arthur-Nyarko, Agyei and Armah (2020) find that the high cost of internet data and digital devices are hurdles that can restrict learners' access to ICT. Mfaume (2019) discussed the barriers to using mobile phones find that the exorbitant cost of mobile ICT devices is an active challenge in the education domain. This is in keeping with the findings of Basar *et al.* (2021); Alavijeh *et al.* (2024), who unpacked the high cost of ICT, so numerous numbers of far-flung rural schools cannot afford to purchase these devices. Similarly, the cost of ICT infrastructure restricts technology adoption in schools in Tanzania (Mfaume 2019). Therefore, policymakers can commit themselves to implementing innovation to uplift rural schools with advanced technology to encounter modern education. Implementing new ideas could help rural schools adapt quickly to the next sphere of Education 5.0.

2.3.3.1 Learners owning the electronic devices

In the last decade, many countries have attested to the increase and availability of electronic devices. The gigantic utilization of mobile devices, such as computers (laptops), tablets, iPads, cell phones, and internet access, has benefits in affluent schools with well-resourced support. Therefore, the potential of learners to own electronic devices to enhance learning can only be realized once electronic devices like computers and/or laptops, cell phones, and internet access have been well prepared at schools, especially in rural schools that are not well-resourced with ICT infrastructure. Based on this background, merely 20.66% of learners used computers for academic purposes in Karnataka (Sampath Kumar and Shiva Kumara 2018). Only 20.66% of rural pupils used computers for academic purposes, indicating a digital usage divide between rural and urban learners in Karnataka.

Lack of access to electronic devices is the key challenge towards the adoption of information and communication technology in South African public schools in poor communities. According to Chomunorwa and Mugobo (2023), merely 58% of learners have no access, which means that they do not own any type of electronic device in public schools in South Africa. Regarding this, 35% share electronic devices, 22% access electronic devices in public school libraries, 13% use family members' electronic devices, and 7% of learners have full access to electronic devices (Chomunorwa and Mugobo 2023).

The use of electronic devices in developing countries has the potential to customize educational context, but overcoming the barriers to access and usage requires coordinated efforts from policy-makers, the Department of Basic Education, Non-profit organizations, communities, and private sectors. So, if all these agencies can work jointly, this could translate education from rural secondary schools into a new standard that will encounter modern schooling. The following section discusses the number of learners who own electronic devices inside the school, outside school and at home. These devices are as follows:

In addition, 33.61% of the learners affirm that they use their mobile phones frequently while studying at home (Gómez-García *et al.* 2020).

a. Computer ownership by learners

The computer is an intelligent machine that performs numerous tasks. Despite the intelligence of this machine, learners in developing countries find it difficult to own this machine. As a result, teachers have decided to implement a new approach to the Bring Your Own Device program at school. This was to reduce the number of learners with no computer access at school. According to Mengistie (2020), in Ethiopia more than 80% of learners with no desktop computers, laptops, or smartphones at home, and after learners leave school, it is difficult to access online assessments because learners do not own computers or internet access at home. Only 55% of learners in Ethiopia have access to computers and other technology devices outside of school (Bati and Wasyhun 2020). A study by Matlala and Kheswa (2019) indicated that 25% of learners used digital devices, such as computers and laptops, to access the internet at Akhuduthamaga Local Municipality, Limpopo province, South Africa. Moreover, learners who own computers perform better in computer skills in South African schools when they are using these applications (MS Word and Internet) (Blignaut, Dednam and Nkalai 2016). Also, 28% of learners own and use the computer as their favourite for reading and writing at Thika High School, Kenya; some learners admire the use of computers because they have good screen readers and 'speech output' that allows blind learners to access computer, socialize with other friends online, and complete online assessment (Gitari 2020). During the pandemic era, only 0.03% of learners managed to use desktop computers to interact with teachers (Tuwei, Florence M. Okari and Omuse 2023). Furthermore, during the pandemic, almost 5-10% of learners continued their studies at home, owning computers and having internet access (Spaull and Van der Berg 2020).

The ownership of computers and the internet is very low in developing countries like South Africa. A study by Spaull and Van der Berg (2020) indicated a low adoption rate of home access to computers and the Internet. So, to narrow this gap, the Department of Basic Education (DBEd) sponsored the Gauteng school with iPad to support learners who do not have access to computers and the internet in school. As it stands, this country (South Africa) is improving in terms of technology; this is consistent with BusinessTech (2024), indicating that 81% of South African learners have access to mobile devices like cell phones, and 31% are on the package of social

networks. Hence, plenty of jobs need to be carried out by the government branches to increase the number of devices owned by learners from 80% to 100%, with a ratio of 1:1 computer ownership in rural secondary schools. The shortage of technologies allows learners to use cell phones (smartphones) at school due to insufficient essential learning tools.

b. Cell phone ownership by learners.

Access to technology inside and outside the school, including cell phones, can reinforce learners learning and emphasize the importance of using technology. Cell phones are trending quickly in affluent schools and even in poor ICT-resourced schools where learners fail to meet societal demands. They are the essential mechanism in the modern era and can provide new learning opportunities. In well-resourced schools, blended learning is not interrupted; learners receive sufficient ICT resources to support schooling (Kizilcec *et al.* 2021). Even though numerous schools in South Africa (SA) ban the use of cell phones, the Department of Basic Education sponsored the Gauteng province schools with iPads fully installed with essential educational software, for example, search engine, internet access, call dial, and so forth (Bejrajh and Themane 2022) . A study by Fernandez (2018); Herselman *et al.* (2019) concur with the ban on smartphones at schools in SA; the huge concern now is why other schools banned smartphones because the Department of Basic Education sponsored schools in Gauteng with iPads. Because 92.1% of the SA population owns cell phones (SANews 2023). In other instances, Theunissen and Siebörger (2023) provided guidelines to the Department of Basic Education, school principals, and teachers to promote and accept the enrolment of tablets by teachers in the classroom.

Almost 81% of learners in South African secondary schools own cell phones (BusinessTech 2024). What is fascinating is that, even in higher education institutions in South Africa, cell phones are used for studies. Fernandez (2018) revealed that 77.5% of learners used cell phones for studies and 72.5% for chatting with peers. 80.6% of poor learners own mobile phones compared to the affluent learners, who own 92.1% (Mutegi 2020); this suggests that learners living in rural areas have low ownership of mobile phones compared to affluent learners in urban areas in Kenya. A study by Nkomo and Matli (2022) argues that “rural students in Beitbridge did not have access to mobile gadgets”. So, to narrow this gap, the Kenya School of Government in Nairobi can focus on the issue of mobile phone ownership in rural secondary schools. In addition, can follow the same rule with the Namibian schools, a study by Mbala (2019) shows that out of 134 learners, 93% of learners own cell phones, and 7% do not own cell phones. It shows that the majority of learners have cell phones and have access to cell phones.

Cell phones are valuable devices not only in South Africa and Kenya but also in other developing countries like Ethiopia and Nigeria. These devices have benefits and barriers to influence in an educational context. Regarding good influence, cell phones are used for educational purposes in schools. According to Bankmycell (2024), 70.33% of smartphone users are in developed countries; by contrast, 29.63% in developing countries, in education level (secondary school), 83%

of learners own smartphones, 12% own cell phones (not smartphones), and 95% own any type of phone. Ethiopia falls under developing countries with 29.63% of users of smartphones, with approximately 95.420,799 of the population living in rural areas in 2022 (WorldBank 2018). According to Bati and Wasyhun (2020), 46.5% of learners have access to cell phones outside of school and 19.2% in other locations except for school. Interestingly, a study by Haruna *et al.* (2016) found that the number of mobile phones does not affect the performance of secondary school learners in Taraba State, Nigeria. This is in line with the number of learners owning cell phones in Namibia. Only 93% of learners own cell phones (Mbala 2019).

It is undeniable, that the ownership of electronic devices like cell phones among rural secondary learners is gradually progressive. From the findings, learners usually share electronic devices for example cell phones and sim cards, only 29.5% own cell phones, 26.1% share cell phones, and 30.7% of learners share the sim cards with friends and/or family members (Mugambi 2022) . This is consistent with the fact that some of the learners in Beitbridge have substantial challenges in sharing mobile devices with their family members (Nkomo and Matli 2022).

Most schools in Kenya do not use ICT for teaching purposes. Those who use Information Technology (IT) do not use IT regularly (Chesire *et al.* 2022). Other learners use cell phones for sexual images (Mugambi 2022), not for schooling. This is in line with the findings of Nkomo and Matli (2022) learners spend more than five hours accessing social media not for studying purposes. A study by Tuwei, Florence M. Okari and Omuse (2023) dissent that learners used mobile devices for another purpose, indicating that 46.9% of learners use mobile devices to interact with teachers via social media platforms such as WhatsApp with 31.3% while other learners use mobile devices to interact with teachers via phone calls and instant messaging (IM). So, this has a negative influence on the adoption of ICT. In addition, other learners make use of cell phones for studies at home, 31.8% of learners in Kenya use cell phones at school or home, while 39.8% use them for the internet and it is used for other purposes, for example, social media, only 11.4% of learners use it for social media and 13.6% for radio (Mugambi 2022). So, this has a positive influence on the adoption of ICT. From these findings, this study suggests that the Kenya School of Government in Nairobi (KSGN) can seek a further approach to improve the ownership of mobile devices in rural secondary learners schools in Kenya. In South Africa, the Department of Basic Education sponsored Gauteng schools with iPads (Bejrajh and Themane 2022) . By doing so, developing countries will leapfrog other Western countries' schools with technology. Inequities in access to technology exist in rural secondary schools, with some learners having limited opportunities for relevant technological experiences, which may affect cell phone ownership.

c. Tablets ownership by learners

Organizations like African SchoolNets advocate for increased access to ICT for African learners, which could potentially improve tablet ownership in rural secondary schools in South Africa.

Efforts to enhance the limited number of tablets available in schools include promoting creative solutions like mobile learning labs to enhance student access to technology.

During the pandemic era, mobile devices gained more attention, and mobile learning labs were implemented to improve limited tablets in schools and make an impact among learners in rural communities. Mobile devices make it easier for learners to share information, learn, and seek information without having to be in the classroom, but in rural areas, they find it difficult to own mobile devices. Only 3% of schools own tablets that learners use, and two schools had eight tables in Kenya (Kerkhoff and Makubuya 2022) . A study by Bati and Wasyhun (2020) shows that learners have better access to ICT devices at home and outside school due to the lack of coordination for teaching with ICT and inadequate capacity for training teachers, leaders, and learners. Even though only 34.8% of learners own working tablets in Adis Ababa, the rest, 82.3%, outlined as network issues (Kelly *et al.* 2019). About 52.6% of learners own (use) tablets to take notes and read e-books and soft copies at school in South Africa (Fernandez 2022). In addition, merely 17% of learners use tablets to access the internet at Makhuduthamaga Local Municipality, Limpopo province, South Africa (Matlala and Kheswa 2019), and merely 0.1% of learners managed to use tablets during the pandemic in Kapseret Sub-county, Kenya (Tuwei, Florence M. Okari and Omuse 2023).

In Europe, 88% and 82% of urban households have access to the Internet and computers, while 78% and 66% of rural households have access (Kennedy, Mejía-Rodríguez and Strello 2022). Hence, 42.5% of households in affluent areas have access to the internet, while 13.7% of poor households have minor access to the internet in Kenya (Mutegi 2020). The comparison of these shows that European schools have better access to the internet compared to African schools. In addition, the use of tablets in classrooms has a positive impact on learners. Accordingly, in the effective use of tablets in Egyptian secondary schools, learners found that utilizing tablets in the classroom enhances learners' creativity and thinking skills and makes teachers more creative (Amer 2020).

d. Learners' internet access

Learners use Internet access daily for academics, while other learners do not use it daily. Previous studies identified the failure of the internet in rural areas. Challenges like internet access have a massive influence on the adoption of ICT among rural secondary learners in schools in developing countries; learners in affluent countries own internet while learners living in North of Sahara Kenya, Ethiopia, Guinea, Gambia, Lesotho, Somalia, Sierra Leon, Mozambique, St. Helen, Chad, Eritrea, South Africa and so on experience enormous predicaments in the ownership of internet.

The rural secondary learners in Malamulele, South Africa, have access to the internet at home and inside the school and mobile devices, such as smartphones and laptops (Nkomo and Matli 2022). Moreover, learners use mobile devices for different purposes, such as music, movies, social media, newspapers, gossip, homework, communications, and so forth (Nkomo and Matli 2022). 25% of

learners own digital devices to access the internet at Akhuduthamaga Local Municipality, Limpopo province, South Africa (Matlala and Kheswa 2019). 13.7% of households in Kenya have minor access to the Internet, while in European countries have better access to the Internet approximately 88% of people living in urban areas and 82% of rural communities (Kennedy, Mejía-Rodríguez and Strello 2022). This shows that affluent countries have better access to the Internet greater than 80 per cent, which is much worse compared to the SSA countries. Tuwei, Florence M. Okari and Omuse (2023) revealed that only 69.8% of learners agreed they owned the internet in Kapseret, Kenya. In Ethiopia, most secondary schools have higher constraints on basic ICT infrastructure, and even minimal computers are not performing accordingly. Only 21% of learners have access to an internet service (Kardefelt-Winther *et al.* 2022).

Table 2.1 demonstrates only three countries in the Sub-Saharan region with the number of learners owning technologies, such as computers (laptops), cell phones, tablets, and internet access. The three countries South Africa (SA), Kenya (KENY), and Ethiopia (ETH) were selected based on specific reasons. *Firstly*, between the Sub-Saharan African settings, plenty of countries lack a developed secondary education domain and essential resources to underpin ICT infrastructure like computers (laptops), tablets, cell phones, and internet access, thus were not suitable in this study on ICT adoption among rural secondary learners schools in developing countries. *Secondly*, SA (81%) is considered the highest ownership of cell phones at school, and this study was conducted in South Africa. *Thirdly*, KENY (69.8%) has the highest number of learners who have better internet access compared to other devices owned by learners in Kenya and South Africa. *Finally*, ETH has approximately 81% of rural learners, with the highest number of learners owning laptops and desktop computers at school or outside school. Ethiopia is the world's leading expensive internet access Mengistie (2020), which has the lowest number of learners using tables (0.1%). Moreover, Ethiopia has more learners experiencing network constraints at Adis Ababa with 82.3% (Kelly *et al.* 2019). Bati and Workneh (2021) lamented that learners in Ethiopia secondary schools have stronger access to cell phones and other ICT resources at home and outside the school with superb internet access outside rural school contexts.

Table 2.1: Electronic Devices Owned By Learners In Three Developing Countries In The SSA Region.

Country	***Computers or Laptops***	***Cell Phones***	***Tablets***	***Internet Access***
South Africa (**SA**)	25%	81%	52,6%	25%
Kenya (**KENY**)	0,03%	80,6%	0,1%	69,8%
Ethiopia (**ETH**)	81%	46,5%	34,8%	28%

Based on the diagram in Figure 2.1, computers or laptops and electronic devices, Ethiopia (81%) learners are leading the ownership, South Africa (25%) is sitting at position two with 25% of the ownership, followed by Kenya (0.03%) with the minimal percentage of ownership. In the second

cluster of cell phone ownership, South Africa (81%) is leading, followed by Kenya (80.60%) with a difference of 0.4%, and Ethiopia (46,50%). The third cluster of tablet ownership by learners is arranged as South Africa (52.60%) leading, followed by Ethiopia (34.80%), and Kenya (0.10%). Finally, the last group of learners owning the internet in developing countries, is Kenya (69.80%), Ethiopia (28%), and South Africa (25%).

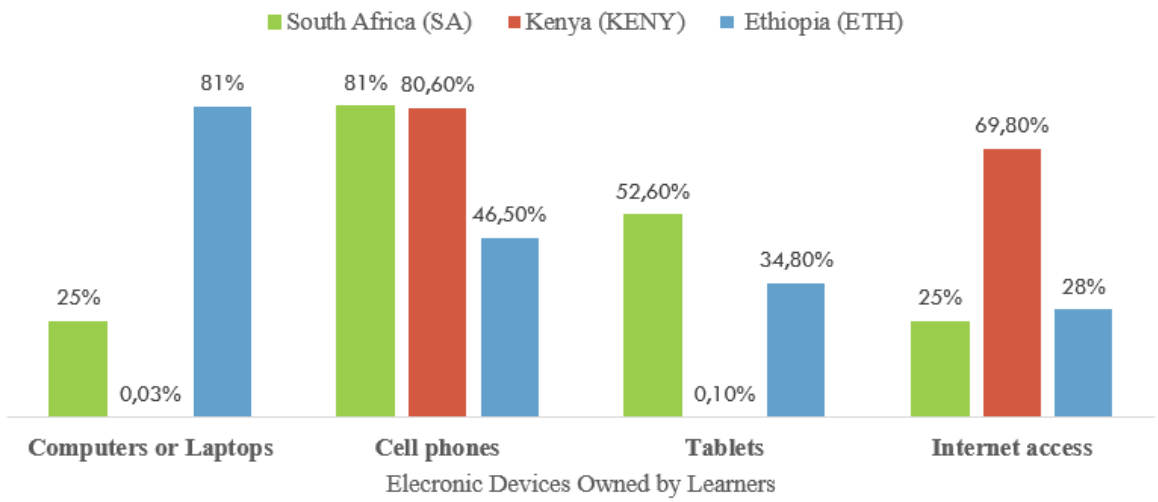

Figure 2.1: Percentage of learners owning (use) electronic devices in developing countries

2.3.4 The potential of learners owning electronic devices

Learners who possess electronic devices (EDs) can build on collaboration if advocated with integrated ICT infrastructure (computers or laptops, cell phones, and tablets), internet connectivity, reduced internet access and the cost of EDs. These electronic devices have become a requisite in education, with learners being required to own EDs for academic purposes. Although there are benefits like better communication, reduced cost efficiency, time management, and better access to educational materials, there are some dilemmas, such as health issues. Furthermore, learners owning EDs can always introduce innovations in education; hence, parents, teachers, and the government need essential support to merge them into learning settings efficiently. In this, understanding comprehensive ideas of learners embracing EDs can better improve educational challenges and address any predicaments against the studies.

According to Othman, Khairuz and Sumaiyah Jamaludin (2020), reveals that learners using electronic devices show a crucial connection between academic performance and ‘health status’; excessive use of electronic devices (EDs) correlates with poor results of academic achievement but excellent 'health status' among secondary school learners. The majority of learners who spend more time sitting on electronic devices rely more on technology. This is consistent with a study by Nkomo and Matli (2022), which found that learners spend more than five hours accessing social media, not for studying purposes. In addition, Balatoni, Varga and Csernoch (2020) revealed that learners also spend more time on the internet playing games, social media, and video streaming instead of doing schoolwork.

Other learners owned more than one mobile device. A study by Devi *et al.* (2019) found that most learners owned two or more digital devices, leading to the possibility of health issues like “stress,” “headaches,” “anxiety,” and “memory disturbances” due to the overutilization of EDs. Excessive use of more than one electronic device negatively influences academic performance, specifically in minor learners who need parental. Even though EDs have a positive impact on learners in schools, a study by Surendran, Norazlinda and Uh Man (2022) ensures that learners owning EDs, for example, phones and laptops, have a high acknowledgement of Bring Your Own Device at school to improve the accessibility of acceptance technology and lower degree of education in rural areas. In addition, excessive use of EDs by learners can create mental disturbance in the creation of addiction and negative challenges against lifestyle. The 'addiction' to EDs is identical to alcohol, as many learners use social media, play games, watch illegal sites, and so forth (Kumari 2023). This is discussed in a study of the impact of EDs on the lifestyle of secondary learners in school.

Excessive use (daily use) of EDs has high challenges to health that might harm the physical health of learners in schools, not in consideration of learners alone, even in lifestyle. Previous studies investigating ownership of EDs found similar characteristics of excessive use of EDs, such as health problems (obesity, stress, anxiety, headaches, visual issues, musculoskeletal signs, and bruxism). A study by Alturki, Brookes and Davies (2020) found that learners' duration use of EDs, for example, tablets and smartphones, is connected with the high risk of ‘obesity’ in Saudi school-aged children, indicating the possibility of gaining weight. Devi *et al.* (2019); Alturki, Brookes and Davies (2020); Othman, Khairuz and Sumaiyah Jamaludin (2020); (Silva *et al.* 2022) found that excessive use of electronic devices has a crucial impact on health for example (Silva *et al.* 2022) found that excessive use (daily use) of EDs for more than two hours was connected with bruxism in teenage children between the ages of eight and ten years.

Thus, this section recommends that policymakers and healthcare agencies be proactive in introducing awareness of owning electronic devices for academic purposes and healthcare tracking to mitigate these dilemmas so that learners can realize the significance of incorporating ICT in education settings, specifically among rural secondary school learners in developing countries. On top of that, this section motivates the integration, adoption, and use of EDs among rural secondary school learners in developing countries for better improvement of education in rural areas. There must be an implementation to block the negative use of EDs among learners.

2.3.5 The benefits of learners owning electronic devices

Learners owning electronic devices (EDs) have different advantages when it comes to information and communications technology. These machines serve as vital tools for learning, academic performance, collaboration, and planning, and they improve the degree of learning among learners acquainted with these devices (EDs). The use of modern EDs helps to improve reading skills through different applications and prominent electronic devices, such as computers (laptops), cell phones (smartphones), tablets, and internet access. Furthermore, the inclusion of electronic devices

in academia can improve learning styles and make subjects easily accessible. Although electronic devices offer positive outputs in academia, it is important to balance the usage of electronic devices to circumvent the drawbacks of health issues.

Plenty of learners benefit from using electronic devices for electronic assessment due to the high safety, ease of use, effortlessness, and enhanced learning performance, but even so, there are difficulties. A study by Markelova *et al.* (2022) highlighted that remedying the functional vision issues related to excessive use of electronic devices that produce health issues is recommended. It is significant to mitigate the number of hours spent with electronic devices by learners, which would have positive results on the functionality of physical health and could preclude fatigue. So, learners must reduce the number of hours spent sitting on the internet, social media, movies, and games, focus on studies, and do essential duties such as assessment and research. Xodabande and Hashemi (2022) advocated that learners owning electronic devices benefit from easy access to electronic materials and enhance enjoyment.

Owning digital devices enhances academic achievement by facilitating interactive learning, knowledge transfer, and efficiency in gaining knowledge. Moreover, learners also benefit from improved abilities through the use of electronic devices. Learners benefits are those pupils owning electronic devices like mobile devices used for effective learning with the large storage capacity of data and various learning materials. The ownership of EDs by learners allows learners to multitask**,** have quick memory, and keep information; however, using one application in the classroom can help learners achieve higher academic performance (Limniou 2021). Furthermore, learners benefit from owning electronic devices such as cell phones (smartphones) and computers (laptops) for accessing online assessments, social media, and educational materials, which can enhance communication and aid them in adopting advanced ICT (Adriani and Asyifa 2022). Despite the benefits of social media declared by (Adriani and Asyifa 2022), other studies reported that social media have negative effects on learners; learners spend more time sitting on social media (Nkomo and Matli 2022; Kumari 2023), which leads to health issues. Accordingly, merely 11.4% of learners use electronic devices for social media (Mugambi 2022).

Devices like tablets have a massive contribution to learners, with the benefit of helping learners research and be simple (Fernandez 2022). According to Moca and Badulescu (2023), these devices (EDs) assist secondary learners in having a positive influence on mobile learning and assist in the improvement of economic education through technology. This section shows the benefits of owning EDs by learners. Performance improvement is the significant benefit reported in this section. So, it is very important to bear in mind that, the ownership of EDs has both benefits and barriers, but this section discusses the benefits.

2.3.6 Computer-to-learners ratio

At this particular juncture, school computer access is now a necessity, not a 'commodity.' Computer access is a substantial tool for teaching and learning, as is acting on behalf of paper, pens, textbooks, and chalk. Despite that, rural pupils still have no access to a computer, and they

share one computer. According to Goldschmidt (2020), some families may share one computer, and others do not own even one computer at home.

There are many barriers to adopting and using ICT among rural secondary learners. These incorporate insufficient ICT infrastructure, for example, poor internet connection, lack of ICT skills, and lack of desktop computers and computers in rural schools. For example, a study by Chisango *et al.* (2020) revealed that in Western Cape, South Africa, learners shared computers, resulting in only a few learners developing ICT skills. Moreover, Chigona *et al.* (2010) revealed that the Khanya Project schools had 25 desktop computers to accommodate more than 700 learners in the village, resulting in overcrowding in the computer laboratory (Lab). Yet, teachers who are not making use of technology for pedagogy revealed that the 'high learner-computer ratio' demotivates learners from using technology (Chigona *et al.* 2010). In addition, teachers responded to a conducted study by Chisango *et al.* (2020) that the school merely has 25 computers shared with 500 learners registered at secondary schools in Eastern Cape, South Africa; it is difficult to use them because they are limited to underpin learners in our school.

Believing in ICT with high trends and benefits. Often, countries in the world attempt to lower the learners-own-computer ratio to 1, meaning that one student per computer (Thy and Ann 2023). For example, in Australia, massive funding was granted to carry the Digital Education Revolution (DER) to ensure that all secondary learners have access to their computers (Keane and Keane 2020). The big issue is that once the funding has expired, the DER will never proceed with providing essential resources at school; the principal has to seek another funding for the 1:1 program (Keane and Keane 2022). Accordingly, the digital education revolution program changed the crisis of sharing computers to the admiration of 1:1 computers per student, increasing the chances of practice, teaching, and learning (Keane and Keane 2020).

Based on Chigona *et al.* (2010) discussion on Khanya Project schools, Keane and Keane (2020) DER program, Keane and Keane (2022) 1:1 program, and one learner' per computer (Thy and Ann 2023) shows that this challenge of the computer learners ratio still exists if you have more than learners in 25 computers does not make sense to still limit the access to computers at school. So, the government needs to be proactive to end the progressive challenge. Therefore, 80% of learners do not have access to laptops, smartphones, and desktop computers in Ethiopia Mengistie (2020), meaning that 20% of learners share devices and do not own any type of device.

2.3.7 The infrastructure damage

There is high damage to the ICT infrastructure where the rural schools are located, and some of the devices are stolen from schools. The infrastructure building with ICT resources is sometimes damaged (broken down) by constructors being employed to perform a certain task at school. This breakdown of ICT infrastructure can cause havoc or delays in connecting networks and other ICT resources. In this, constructors also limit technology adoption by cutting Fiber cables. This is validated in a study of digital doings through breakdowns, which revealed that one of the

constructures was hired with a job to dig underneath the surface, resulting in the cut of network wires at school. The network outage took almost one week to be restored, and the IT expert has decided to organize an alternative building with fully installed ICT infrastructure like a stable network (Wi-Fi); some of the classes moved to an ancient library with no advanced technologies like an interactive whiteboard, black-board (BB), and projectors (Alirezabeigi, Masschelein and Decuypere 2020). Therefore, constructors are among the factors affecting the widespread adoption of ICT in schools. It is recommended that the sub-constructors be lectured or furnished with mandates for any commodity that might be disrupted during the operation.

Technologies like projectors play a significant role in the presentation of schoolwork on the whiteboard. Despite that, ICT infrastructure in schools is being harmed. According to Chirwa and Mubita (2021), a study on the use of ICT in teaching in selected schools of Petauke district, Zambia revealed that one primary school in Zambia did not have a projector; the reason that the projector was damaged and has never been repaired. Not by considering the breakdown or damage of technology devices, but by examining the theft and vandalism of ICT infrastructure, the adoption of information and communication technologies in schools is lower. Chisango and Marongwe (2021) discussed the 'theft and vandalism of ICT infrastructure at schools'; the school principal raised serious concerns regarding the theft and vandalism of ICT resources. "The DoE rolled out computers in the Gauteng online laboratory twice, but all the computers were stolen." Moreover, "The school principals concurred that learners in the community were also robbed of their tablets." This study recommends the diffusion of law enforcement to address the issue of theft and vandalism of ICT infrastructure in schools by the dissemination of security guards around the school daily from 06H00 pm to 07H00 am. This section shows that theft and damage of ICT infrastructure reduces the adoption of ICT education context.

2.3.8 Building infrastructure

The movement of ICT is gradually gaining momentum in the developing world; hence, there is still a massive gap between the need for building infrastructure, for example, training centers, libraries, roads, and computer Labs, to acknowledge the advent of ICT in schools. The major school factor is the insufficient capacity building centers for training teachers and teaching learners basic ICT skills (Bati and Wasyhun 2020). Alongside this, extant literature on the environmental impact of ICT implies that policymakers are speculated to build infrastructure. Against this situation, this section discusses the lack of building infrastructure in rural areas, such as libraries, roads, electricity, and labs, that are unable to adopt ICT. Infrastructure is understood as the interconnection of academic work, such as ICT support structures that enable learners to participate easily with teachers and peers to enhance the process of learning, communication, time management, big data storage, and so on.

Thy and Ann (2023) results revealed that Cambodian high schools' tranquillity infrastructure like advanced libraries, Labs, and electricity. Furthermore, despite the quality of infrastructure, there is a limited number of classrooms, extended vast class sizes, and an extensive number of learners

-to-teacher (Thy and Ann 2023). The small capacity of classrooms can cause disruptions inside the classrooms or computer labs; the high number of learners in one classroom makes them misbehave not shush. Build infrastructures and amicable systems to accommodate hybrid (virtual) classes (Rafiq *et al.* 2021). So, people in power can build infrastructure, as claimed by (Rafiq *et al.* 2021). Align an existing education with advanced technology is feasible when the government, Department of Basic Education (DBEd), private sector, and other stakeholders can build enough infrastructure with modern technology to ease learning (González-Pérez and Ramírez-Montoya 2022).

The missing building infrastructure for teaching and learning activities is an obvious scenario in school development; they take it as an unimportant challenge the building of physical infrastructure, for example, roads, classrooms, libraries, cables, fibres, and so on (Børte, Nesje and Lillejord 2023). This is because not enough funding has been invested in supporting ICT (Rana, Greenwood and Fox-Turnbull 2020). Taking for granted the building infrastructure reduces the adoption of technology, specifically in rural societies, where essential services are not delivered. A study by Rana, Greenwood and Fox-Turnbull (2020) found that in 2015, one had lost its Labs due to natural disasters, for example, an earthquake never being built again; on the other side, others decided to shut down the Labs due to unforeseen reasons. This shows that natural disasters are one of the dilemmas impeding infrastructure construction and technology adoption. In addition, lightning is a natural factor that might limit the adoption of ICT. These natural factors, earthquakes, and lightning, vandalize the infrastructure; the following section discusses the digital literacy and ICT skills among learners and schoolteachers.

2.3.9 Digital literacy and skills

Umar and Jalil (2012) find a disparity in ICT skills among learners in rural and urban schools. Previous studies reported the challenges of ICT skills (e-Skills) in developing countries, rural areas, and impoverished households. Chen *et al.* (2019) proposed a model to promote primary and secondary school teachers' use of ICT to improve the quality of teaching; the designed model indicated ICT teaching skills as a significant factor that impedes schoolteachers from using ICT in developing high-quality teaching activities. The government could launch digital literacy projects to teach ICT skills to learners residing in impoverished areas (Alderete 2019). These projects could help learners in rural areas acquire essential basic skills of ICT application that will produce high-quality education among learners in rural schools. The use of ICT in the teaching and learning process in secondary schools was reported as low due to the low skills of the schoolteachers Haji, Moluayonge and Park (2017) and teachers' knowledge of ICT (Bakari and Ali 2023).

The ongoing challenges of unskilled schoolteachers and learners are often reported in studies; for example, Atman Uslu and Usluel (2019) developed two types of skills for example, "basic competence" and "advanced competence", and described "basic competence" as the main focus of how to use computers and the internet, and "advanced competence" focuses on eLearning designing basic projects and developing learning materials with ICT. Novice schoolteachers in

ICT might prefer introductory courses and enough time to learn new ICT skills, but teachers with an understanding of technology might need advanced courses. Consequently, training courses should be designed to meet schoolteachers and learners with different needs (Kim and Park 2018). As discussed above, these projects could help rural learners acquire essential basic skills of ICT application that will produce high-quality education among learners in rural schools. Teaching basic skills, focusing on internet connection and using technologies, could help learners with no ICT and network usage skills. The Internet of Things (IoT) is a new technology, so teaching learners basic connecting skills, such as Fifth-generation wireless (5G) networks, Wireless Fidelity (Wi-Fi) networks, and much more wireless, is imperative. The deployment of IoT in rural schools could be imperative in remote healthcare and learning. Teenagers in non-developing countries use mobile health systems to access health services (Cussó-Calabuig, Farran and Bosch-Capblanch 2017).

2.3.10 Perceived benefits of ICT

To acquire perceived benefits from integrating, adopting, and using ICT, typical skills are needed, such as ICT skills and leadership skills (management skills). Leadership skills refer to developing ICT applications to support managerial duties in the business.

In an empirical study by JG, Kosgey and Sang (2012), the respondents agreed that ICT adoption and perceived use in schools have benefits, data improvement, communication improvement, and successful management of learners' records. In addition, the school leadership does not realize the perceived benefits of ICT adoption and perceived usefulness in managerial duties. This is due to a lack of ICT skills and financial (socioeconomic) barriers.

Kothari (2004) recommended that Intelligent Computer-Assisted Instruction (ICAI) programs can solve any circumstance, identify learners' misunderstandings, opt for recommended teaching styles, and continue communicating with learners based on studies and how learners ponder, learn, and solve errors. Even so, Kothari (2004) understands that these perceived benefits are not part of the developing countries, where there are barriers to electricity, limited network access, lack of ICT infrastructure, deficiency of ICT training, and cost of distance learning (Davis, Bagozzi and Warshaw 1989). These perspectives can be applied in rural schools where ICT is gradually being used due to the abovementioned barriers. These are the three best ways to support education in rural schools to ensure that rural learners are acquainted with ICT:

a. **Support educational technology**- provide ICT services that are compatible with schoolteachers and learners to meet 4IR and blended learning,
b. **Support online learning**- provide learners with stable Wi-Fi networks and data bundles to ensure learners and teachers are well-connected and
c. **Support management with quality services in schools**- provide quality development in the classroom and develop modern computer laboratories with modern technologies (Kenya 2005).

The use of mobile devices in secondary schools remains an issue; however, empirical evidence from secondary school teachers and mobile learning(m-Learning) remains. Based on this, a study by Nikolopoulou (2020) identified perceived benefits and barriers. The perceived benefits are motivation, active engagement, admired lessons, accessibility, and learners acquainted with technology. The barrier reported by teachers is the lack of ICT equipment. Teachers raise concerns regarding mobile phone use in school, difficulty controlling them, unbearable noise in the classroom, and havoc. The prompt concern spat by schoolteachers refers to government policy and initiatives below.

Rabah (2015) results displayed an increasing number of learners' engagement and improvement of the teaching and learning process as the perceived benefits of ICT integration in English Québec Schools. Moreover, participants stated that these barriers are the main factors that impede ICT integration, for example, lack of supporting school leaders, lack of investment, ICT infrastructure, funding, curricular planning, and no professional development and support (Rabah 2015).
Previous studies by Paunova-Hubenova, Terzieva and Todorova (2019); Aruleba and Jere (2022) indicate that investment in schools for purchasing ICT infrastructure is not at the apex of government resolutions. The school receives a limited state budget, not including ICT resources budget funds. Due to the limited funding from the state, the school cannot purchase technology devices because they are pricey. The budget for ICT should embody ICT infrastructure and software(updating and upgrading). However, ICT has more perceived benefits in the educational sector, finance, health, agriculture, security, entrepreneurship, etc. This is confirmed by Thottoli and KV (2022) findings, which reported that ICT adoption, ICT competency, and ICT training positively affect audit practice.

After carefully unpacking, distinguish the perceived benefits of ICT adoption. There is no doubt and disbelief that if policymakers and governments can focus on these benefits, developing countries and rural secondary schools can collaborate in adopting ICT among learners in developing countries.

2.3.11 Barriers to ICT

In developing countries, experiencing barriers to ICT adoption is the norm compared to developed countries. Adopting ICT in rural secondary schools (RSSs) can be challenging due to several challenges.

Budget constraints and lack of home internet access for learners are the overarching factors of ICT adoption among RSSs (Kormos and Wisdom 2021). Lack of internet access (Coopasami, Knight and Pete 2017; Barnard-Ashton *et al.* 2018; Harerimana and Mtshali 2018; Madida, Naidoo and Rugbeer 2019; Chisango *et al.* 2020) is a challenging factor among learners in rural schools. Becta (2004) proposed two barriers affecting teachers to integrate and adopt ICT for example:

A. **Individual**- refers to learners' barriers (availability of time, attitude, self-efficacy, resistance to change).

B. **Institutional**- refers to school barriers (lack of ICT training, access to the available ICT resources, lack of ICT infrastructure, and leadership from top management). Khalid, Islam and Nyvang (2013) found barriers to be related to the purchase of computers in developing countries:

C. **Cultural** (for example, subject culture, pedagogy)- refers to the culture between the local communities and rural schools in developing countries. If someone plans to buy a computer, they find it difficult to trust anyone and get advice on which machine is recommended. The lack of ICT skills causes this; what is missing is a professional IT specialist or expert who will advise teachers and learners in rural schools and be acknowledged as a professional expert in ICT. Khalid, Islam and Nyvang (2013) state that local investors trust the change agency to assist the local community in rural areas in buying computers. Therefore, it is a wise dream to allow the change agency to spend more time in rural schools to stimulate change in culture by providing knowledge.

D. **ICT infrastructure** (for example, technology, access to the available devices time)_It is inevitable that rural schools in developing countries are experiencing infrastructural barriers. These barriers are difficult to deal with since often studies report on these barriers. ICT can add more to the quality of education, but the unavailability and insufficient of ICT infrastructure (Mhlana, Chipangura and Twinomurinzi 2021; Mahlo and Waghid 2022; Teye and Duah 2022; Van Greunen and Fosu 2022; Gamit 2023; Shala and Grajcevci 2023; Zenda and Dlamini 2023) hamper the digitalization of education, specifically in developing regions. Moreover, the poor quality of internet access created unanswered questions for leadership in rural schools. Plenty of learners raised similar queries in this regard. So, it is difficult to travel from rural to urban areas to purchase ICT devices and return to rural areas (Khalid, Islam and Nyvang 2013). Moreover, there is a lack of internet connection.

E. **Knowledge** (for example, ICT skills, technology, technology support pedagogy, and technology-related classrooms)__ knowledge is essential for the success of educational technology; without ICT skills, there is no success in educational technology. The ongoing challenges of ICT skills are often reported in studies; for example, Atman Uslu and Usluel (2019) developed two types of skills for example, 'basic competence' and 'advanced competence', and described 'basic competence' as the main focus of how to use computers and the internet, and 'advanced competence' focus on eLearning, designing basic projects and develop learning materials with ICT. Teaching basic skills, focusing on internet connection and using technologies, could help learners with no ICT and network usage skills. Empirical evidence from the study by Khalid and Nyvang (2014) shows that the participants reported skill as the barrier to technology operation in the classroom and management.

Madida, Naidoo and Rugbeer (2019) revealed a few barriers hindering the adoption of ICT in rural schools at King Cetshwayo District Municipality (KCDM). These barriers are the lack of ICT infrastructure, maintenance of hardware and software, ICT as a priority, ICT interests, and ICT

skills. Furthermore, Irwahand *et al.* (2022), in the investigation of perceived barriers to adopting ICT in physical education, the results displayed seven related barriers that were significant in the adoption of ICT these are lack of ICT infrastructure, lack of internet access, lack of pedagogical support for teachers, insufficient content of language, peer pressure, poor understanding the benefit of using ICT in teaching and learning process as impediment barriers in the adoption of ICT.

Addressing these barriers often requires a multifaceted approach, including investment in infrastructure, teacher training, and community support. Collaboration between government, non-profit organizations, and local communities can help create a more supportive environment for ICT adoption in rural schools.

2.3.12 Financial barriers

This section discusses the impact of funding in developing countries. An extant literature discussed this barrier in many countries where low and middle-income households sustain critical difficulties in adapting. Barbier and Burgess (2020) state that in the non-attendance of financial support in developing countries, it seems as though this deterrent factor should be combatted.

For example, socioeconomic, poverty, low household income, and high cost of ICT devices) is another barrier in the educational technology and ICT sector. The World Bank (2024) in the International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database reported that from 1990 to 2021 an individual's access to the Internet in the Sub-Saharan Africa (SSA) regions recorded 36%, and the economy recorded 36%. In addition, countries, for example, Seychelles-2021 (82%), Gabon-2021 and South Africa-2021 (72%), and Cabo Verde-2021 (70%) have better ownership of the economy and internet. This is unfamiliar to the countries; for example, Congo Republic (9%), South Sudan-2020 (7) Burundi-2021 (6%), and Somalia-2017 (2%) have lower-level economies. As a result of this, the African Union (AU) needs to step up to sustain the economy of the SSA regions by addressing the predicaments of internet access and the economy of developing countries compared to the Western and Northern parts of the globe have more seamlessly adapted to these challenges of ICT adoption. As a general-purpose technology, it is used as a catalyst tool to alleviate socioeconomic (Zhang, Gong and Zhang 2022). These results show gloomy hopes in rural schools in developing countries since teachers and learners do not have enough internet access Alderete (2019); (Diaz *et al.* 2021); Aruleba and Jere (2022); glooming hope can develop negative effects. The following section discusses the use of ICT in the classroom.

2.4 Benefits of Information and Communications Technology Adoption

The consciousness of the necessity of Information And Communication (ICT) technology in real-life situations has gained recognition, specifically in education, which seems like a prerequisite mechanism for schoolteachers and learners at schools. This study investigates factors affecting the widespread adoption of information and communication technology, so it is the best way to present the benefits of ICT adoption in the education sector among teachers and learners. Teachers and learners must collaborate to ensure that they make information and communication technology a

successful factor in rural communities by searching for new information nationwide. Schoolteachers need to develop modes of groups appealing to learners to apply information and communication technologies. By doing so, learners will form teamwork and socialize via Facebook, WhatsApp, Skype, Microsoft Teams, Edmodo, etc. Forming teamwork could positively affect information and communication technology since they could form partnerships during the study period. The following are the benefits of ICT adoption.

2.4.1 Collaboration

The use of technology at schools can promote 'collaboration' and communication (Chen and Bryer 2012). In terms of collaboration and communication, it allows both teachers and learners to use knowledge, motivation, and skills to asynchronously and synchronously dialogue in terms of communication and collaboration with different people (Law, Woo and Wong 2018; Al-Ansi, Garad and Al-Ansi 2021). Of course, in rural schools, which is the main target of this study, it has been reported that collaborative technologies can contribute to collaboration (Wilkins, Phillimore and Gilchrist 2016) and to 'innovation' in the school environment by redefining tasks (Lindsay *et al.* 2018). As stated by Chen and Bryer (2012); Law, Woo and Wong (2018) above. Using communication with technology can help learners hear and comprehend every lesson properly. For example, using Microsoft Teams can improve communication because learners can listen to recorded sessions, although there is a poor network in rural communities. Recent findings found that almost 80% of rural areas lie outside the 4G range, even in the United Kingdom (Tang *et al.* 2021). Also, learners perceptions during the coronavirus disease (COVID-19) era highlighted that learners felt lonely, could not share information with peers, and experienced poor-quality audio and video due to poor network connectivity (Jena 2020).

Collaboration helps learners improve their communication skills and creativity (Henderson 2020). As technology persists, people try to find various ways to communicate with others and try to figure out the activities that can be applied virtually using advanced communication technologies, for example, Microsoft Teams (MST), Zoom, Google Meet (GM), YouTube Live (YTL), Facebook Live (FBL), Skype, WhatsApp, and Hangout. Entrepreneurs often use the above communication tools to attend meetings, conferences, workshops, and seminars (Prasad *et al.* 2020). In a study conducted by schoolteachers and learners, teachers reported that they used information and communication technology to expound so that learners could easily catch up (Tamara, Hermansyah and Marleni 2024). This catch-up includes the use of recorded sessions, the integration of these communications platforms in education settings can deliver positive results and make jobs easier as learners can share their assessments via these platforms. The integration of ICT could serve the amount of time.

2.4.2 Integration

'The integration of ICT in education can enhance administrative efficiency' (Venkateswaran *et al.* 2024). The integration of tablets in the classroom serves multiple functions, such as access to many different educational devices, cameras, internet, microphones, and speakers (Kim, Choi and Lee

2019). The 'combination' of digital devices with modern software can bring innovation to rural communities. The integration of tablets in schools has increased more in recent years. A study by Otterborn, Schönborn and Hultén (2018) illustrated that this tool (tablet) can improve 'collaborative' skills. Teachers transit from 21st-century knowledge to the modern education system by integrating ICT into new technology to adapt to teaching, so it is imperative to furnish various supports that will connect ICT skills (Alieto *et al.* 2024). As declared, tablets must be integrated into classrooms and computer labs in all schools, and learners must have access to the internet and modern software. "Currently, educational institutions worldwide are integrating ICT with the teaching and learning process to provide knowledge and skills to the learners to meet the challenges of the educational environment." (Ugwu and Nnaekwe 2019). These software and digital devices must be used effectively to overcome the challenges that often influence the usability of technology in the Sub-Saharan regions.

2.4.3 Usability

The usability and use of ICT will improve the schooling of learners (Henderson 2020). Effective use of ICT can produce quality education and improvement, deliver changes, alleviate costs, reduce time consumption, and facilitate life. So, it is the best way to use technology effectively to meet the needs of technology; failing to do so may hinder the widespread adoption of ICT. Based on the improvements in ICT offerings, a better understanding of the policymakers is needed to adhere to the preceding perspectives. As stated by Tamara, Hermansyah and Marleni (2024), 'In the world of education, technology is developing rapidly after the Covid-19 pandemic because the pandemic has forced digital changes in the world of education and we need a good understanding and knowledge about the types of learners who use digital technology in the learning process.' Moreover, it makes communication (Tamara, Hermansyah and Marleni 2024), so the Department of Basic Education must initiate ideal innovations to improve pedagogy competencies and skills.

2.4.4 Improve skills and knowledge

Often, learners keen on using information and communication technologies during their studies are expected to use technology wisely as expected. Extant literature ensures that technology can improve the educational sector, 'students will improve their interpersonal skills' (Almerich *et al.* 2020). Moreover, the finding indicates a positive relationship between ICT skills and a high level of thinking and building teamwork competencies (Almerich *et al.* 2020). Different communication platforms and digital technologies can be used to scrutinize which is best for schoolteachers and learners. The experimental could assist in the improvement of rare ICT skills; this is discussed in the review of factors affecting ICT from rural Saud Arabia, distinguishing drawbacks such as lack of knowledge about information and communication technology, low level of government support, 'lack of ICT infrastructure' and lack of support from the private sector have a great impact in the adoption of ICT (AlBar and Hoque 2019).

2.5 ICT adoption theories and models

This study uses the Technology Acceptance Model (TAM), which refers to the Information Systems (IS) theory, which models how users can accept and use Information Technology (IT). This typical model was proposed by Fred Davis and Richard Bagozzi (Davis, Bagozzi and Warshaw 1989). The model suggests that when a user is presented with a new technology, several factors influence their decision regarding how and when they will use it. This includes Perceived Use (PU) and its Perceived Ease of Use (PEOU) to determine behavioural intention to use IT, as shown in Figure 2.2. Davis (1989) explains that both PU and PEOU are used to encourage the implementation of positive attitudes in the use of technology and suggests that when PU and PEOU are not disentangled joined together, they usually use increased Behavioral intention (BI) to use technology. Previous technology adoption studies are based on behavioural sciences (Mishra, Shukla and Sharma 2022). The TAM is investigating how PU and PEOU affect attitudes toward the use of technology. Davis (1989) asked, "What causes people to accept or reject information technology?". Many factors may affect the use of technology, but a previous study has identified two crucial hindrances. Firstly, "use or not" people believe that technology can help them perform their jobs better, which is called PU. Secondly, if a user believes that a given technology is useful, they believe that the technology is robust to use, therefore, the ability to use it is low. Perceived ease of use causes this.

Therefore, this section answers the study's aim by developing a new related model to examine the factors affecting the rural secondary-level learners' behavioural intentions to adopt ICT at school in developing countries. The following section discusses the technology acceptance model.

2.5.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) is one of the most widely used conceptual frameworks in determining technology acceptance, integration, and use, and has been used in different educational sectors. The main goal of the technology acceptance model is to uncover the underlying processes that determine the success of technology implementation. It aimed to help predict user behaviour and provide a theoretical explanation for the successful implementation of technology. Also, it had the practical objective of informing practitioners about measures they can take before implementing a new system. Fred Davis and Richard Bagozzi proposed this typical model (TAM) (Davis, Bagozzi and Warshaw 1989). The technology acceptance model was originally developed from (Ajzen 1980) Theory of Reasoned Action (TRA). The TAM aims to explain how users use a technology called perceived usefulness. The technology acceptance model has been developed to be a key model in understanding human behaviour in accepting and rejecting technology in life and technology learning. Fishbein and Ajzen (1975) developed TRA to predict and understand human behaviours and attitudes. In this model (Figure 2.2), only two models affect an individual's use of technology perceived use and perceived ease of use, as discussed above in ICT adoption theories and models.

Perceived use here is defined as a degree to which a learners believes that using technology in rural schools would improve learners performance in developing countries. Moreover, it is defined as the degree to which the user (learners) believes that using technology can improve performance in the teaching and learning process. This comes from the definition of "useful," which means to use something advantageously, while perceived ease of use here is defined as a degree to which a learner believes that using any type of technology is free of charge. This comes from the definition of "ease," freedom from difficult challenges in using ICT; it is also defined as the degree to which the user (learners) believes that using technology can improve performance in the teaching and learning process. It also refers to the extent to which a user believes applying a technology will be effort-free. An attitude towards using technology is suggested to affect the intention to use technology. Davis (1989) implies that PU is a straight variable that indirectly impacts the intention and attitude. In addition, perceived ease of use was hypothesized to influence perceived use directly. This suggests that without considering the value of technology, learners will never use information technology if they are adamant and find it challenging to use information technology.

In previous studies, the technology acceptance model has been investigated in various sectors, for example, agriculture (Castiblanco Jimenez *et al.* 2020), healthcare (Rouidi *et al.* 2022), and e-learning (Tarhini, Hone and Liu 2013). The TAM was designed to investigate technology acceptance in business and commercial settings, even though there is no sufficient TAM in educational technology (Drennan, Kennedy and Pisarski 2005). Dishaw and Strong (1999) suggested that education on TAM is needed to alleviate its extent. Notwithstanding the praise of TAM, to know user technology (Buabeng-Andoh, Yaokumah and Tarhini 2019), it is recommended to use technology in schools and do more studies on adopting technology, specifically in rural schools in developing countries. A study by Teo and Van Schaik (2012) reported that studies on TAM are often reported in Western regions, while there is a deficiency of studies reported in Sub-Saharan Africa (SSA) regions. This is in line with the aim of this study, which is to investigate factors affecting the wide adoption of ICT among learners in developing countries (SSA regions); many studies have reported this above. Furthermore, a study by Buabeng-Andoh, Yaokumah and Tarhini (2019) first attempted to verify previous studies' findings to investigate learners' intention to use technology in developing countries.

"The advantage of TAM is that it is specifically designed to address the acceptance of IS technology." (Oye, Iahad and Rahim 2014). Even though the TAM was developed to address the acceptance of technology, the user (learners) has a different perspective and behaviour if they are using technology, such as the Internet. Balatoni, Varga and Csernoch (2020) learners spend more time sitting on the internet playing games, social media, and video streaming instead of doing schoolwork. This behaviour should be discussed in TAM. Behavioural intention is usually defined as an individual subjective norm that the user performs in a specified behaviour; subjective norm refers to the self-efficacy that all people who are important to him/her usually think he/she should or not perform the behaviour in the task (Davis 1986).

Despite the use of TAM as the main conceptual framework to address the issue of technology acceptance, the main aim of this study is to exhibit many factors that affect the adoption and attitude toward adopting technology in rural secondary schools among learners in developing countries. To acquire the findings of this study, the TAM is employed to add the following variables: perceived usefulness, perceived ease of use, attitude, and behavioural intention. Davis, Bagozzi and Warshaw (1989) reported that attitude only partially mediated the effect of perceived use and perceived ease of use on behavioural intention. On this, attitude towards use is disentangled from the parsimonious TAM. This is in line with empirical evidence conducted by Davis and Venkatesh (1996); (Venkatesh and Davis 2000) reported that "attitude only partially mediates the effect of PU on BI, thus suggesting that attitude could be excluded from the model." However, attitude toward use is excluded in Figure 2.2 TAM (Davis and Venkatesh 1996; Venkatesh *et al.* 2003; Roberts, Ghazizadeh and Lee 2012).

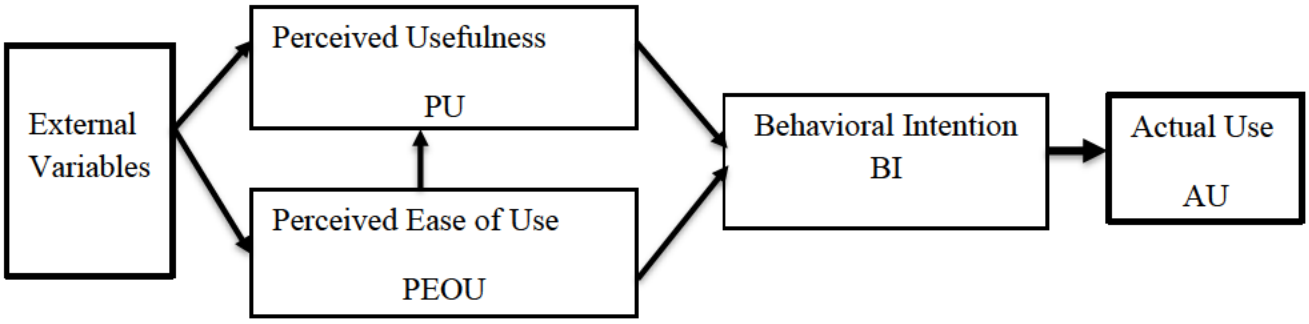

Figure 2.2: Technology acceptance model (Davis and Venkatesh 1996; Venkatesh *et al.* 2003)

The theory of Reasoned Action posits that the main predictor of human behaviour is individual behaviour, although the intention is usually determined by user attitude and social influence. Behavioural intention is generally defined as an individual subjective norm that the user performs in a specified behaviour, subjective norm refers to the self-efficacy that all peoples who are important to him/her usually thinks he/she should or not perform the behaviour in the task (Davis 1986).

2.5.1.1 Barriers Of The Technology Acceptance Model (TAM)

This study uses two theoretical models, namely the TAM and UTAUT models. The reason for this, with the help of the UTAUT, is that the TAM model has limitations as it does not consider social influences in using and utilising new technologies. Moreover, TAM has different limitations, such as not extending the original (Alshammari and Rosli 2020). The technology Acceptance Model is considered a general theory that may not sufficiently explain user acceptance of technology; the belief factors of perceived use and perceived ease of use can also be influenced by external factors that affect technology usage Davis (1989). The UTAUT theoretical model should be involved (Mardiana, Tjakraatmadja and Aprianingsih 2015). As demonstrated by previous research, the

technology acceptance model is one of the most used models to measure the adoption rate of new technology systems. However, the TAM has a drawback. It only includes a limited number of variables related to a system's capabilities without considering the social roles and surrounding environment that may affect technology adoption (Malhotra and Galletta 1999).

Even though TAM is widely used in different circumstances and is considered a reliable model, it will never solve the technology factors alone. For example, extended TAM by incorporating new external variables like self-efficacy and perceived credibility, the results showed extraordinary improvement in the model compared with an original TAM (Luarn and Lin 2005); meanwhile, Mathieson (1991) found that although the technology acceptance model could predict user adoption, it lacked explanatory power for the main constructs of perceived usefulness and ease of use due to its generality.

According to Brezavšček, Šparl and Žnidaršič (2014), the acceptance of technology is influenced not only by perceived ease and usefulness but also by external factors that can affect users' behaviour towards a specific system. As a result, recent research has expanded on the original TAM to explore these constructs further and better understand how users adopt and utilize technology, ultimately increasing the model's explanatory capabilities. Venkatesh and Davis (2000) developed TAM2 to enhance the explanatory power (R^2) of TAM by overcoming its drawbacks. It considers the social impact, for example, subjective norms, image, and cognitive instrumental processes, including output quality, job relevance, and result demonstrability.

According to Manueli, Latu and Koh (2007), the research on ICT adoption reported that the technology acceptance model does not consider personal and control factors in shaping behaviour. In addition, the TAM does not take into account economic factors or outside influences from suppliers, customers, or competitors (Van Akkeren and Cavaye 1999). While originally designed to study technology acceptance in business and commercial, it proved useful in the educational sector, although it was parsimonious for the educational sector (Drennan, Kennedy and Pisarski 2005). Even though TAM is widely used, it has plenty of flaws (Buabeng-Andoh, Yaokumah and Tarhini 2019).

2.5.1.2 Benefits of the Technology Acceptance Model

In 1989, Davis developed TAM, a theory that explains how individuals accept and use technology in information systems (IS). It explains how users accept technology, considering emerging computing technologies and economic viewpoints Davis (1989). This model has five constructs that establish the perspective of TAM. According to Davis (1989), perceived ease of use refers to the level at which an individual believes using a given technology will require less effort. Consequently, TAM requires less effort, which is a strength of this model when adopting ICT. According to Davis (1989), perceived usefulness refers to the level at which an individual believes that using a given technology will increase their job performance. Many users believe that using technology can improve job performance with less effort. Users at the behavioural intention level decide whether to continue using a technology based on their future behaviour (Davis 1989). At

this level, users could make decisions involving technology. All the levels of the technology acceptance model positively influence the adoption of technology innovations, despite the disentanglement of attitude towards use (ATT) level. Attitude level is sometimes detached from TAM. Davis, Bagozzi and Warshaw (1989); Davis and Venkatesh (1996); Venkatesh and Davis (2000) reported that attitude is only a partial mediator of the effect of perceived use on behavioural intention, indicating that it may be unnecessary to include attitude in the model.

By selecting different applications, cultures, and work settings, this study can be expanded to examine the impact of external factors. This extension has the potential to enhance the model's explanatory power. Technology Acceptance Model is a reliable and sturdy model that has been widely tested in various scenarios, contexts, and applications to clarify the acceptance and adoption of technology (Davis 1989). Another study reported that the advantage of TAM is that 'it is specifically designed to address the acceptance of IS or IT (Oye, Iahad and Rahim 2014). Different literature reported that the best levels of using TAM, for example, require less effort, can improve job performance and decision-making, are reliable and sturdy models, and are specifically designed to address the acceptance of technology. On that account, this study postulates that proposing the original TAM and UTAUT plus new models is the best way to address the top five major factors exhibited in the Principal Component Analysis (PCA).

2.5.2 Diffusion of Innovations Theory (DIT)

Diffusion of Innovation (DOI) is a suitable systematic conceptual model for testing whether a proposed system will be used or not Rogers (2003) provides a systematic description of how an innovation is communicated through different technological channels. So, this study is underpinned by Rogers's theory of DOI. The original structure of the DOI was designed as an exploratory structure for adopting ICT in the educational sector (Sarfo *et al*. 2016).

In 1981, Rogers conducted research on telecommunication services in Bonn, Germany. From 1962 to 1995, the researcher focused on developing and publishing DOI. According to the DOI model, utilizing new technology is not an interim behaviour but a conceptual model that takes shape after a series of activities and decisions. For example, when a user shares data and opinions with new technology via communication, the technology repeatedly becomes prominent in the market (Rogers 2003). Rogers, Singhal and Quinlan (2014) argue that many conditions may prevent the success of the adoption of technology; these conditions are (for example, personal limitations) and external challenges (for example, not successful communication channels).

Despite the personal and external challenges, this study reported numerous challenges that hinder the widespread adoption of technology in rural secondary schools in developing countries; little is still known about the process of ICT adoption and integration occurring in the first place, even though rural secondary schools are left behind in ICT. Why are academics willing to adopt ICT in rural schools in developing countries? This study employs DOI, TAM, and UTAUT to analyze major hindrances and provide a useful systematic approach to understanding major factors

affecting the wide adoption of ICT in rural schools and develop a new conceptual framework based on the original model (for example, TAM and UTAUT with DOI theory).

The DOI concept explains technology adoption as" the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003). Moreover, DOI is a type of communication in which the message is important with innovations. Therefore, adopting new ideas in ICT can be escalated if the responsible people are valuable to the individual support and approval of the subjective norms behaviour (Ajzen 1991). This shows that developing a positive attitude toward ICT adoption and embracing technology should be identified as a positive factor among reference people, for example, teachers, learners, school leaders, and school administrators who are influential in academics.

2.5.2.1 Benefits of Innovation Diffusion Theory

There are five major factors influencing the adoption of innovation; the original theory exhibits five major behavioural categories; this theory, the so-called- Innovation Diffusion Theory**,** rates the adoption of innovations and technologies:

2.5.2.1.1 Relative advantage

A degree in which teachers and learners see that an innovation has more advantages compared to an existing technology. For example, if teachers see that Microsoft PowerPoint (PPT) slides are simpler, they will adopt new technology; hence, if Microsoft Excel is not simpler, they will adopt PPT. In addition, WhatsApp is faster, has simpler operations, is low cost, and is easily available. Educational advantages, for example, create a pleasant environment, in-depth acquaintance, and positive dialogue between learners and schoolteachers (Bouhnik and Deshen 2014). In this, teachers and learners could adopt innovations based on declared advantages.

In a study, the participants mentioned the technical advantages of WhatsApp, such as its simple operation, low cost, availability, and immediacy. They also referred to educational advantages, such as the creation of a pleasant environment and an in-depth acquaintance with fellow pupils', which positively influenced the manner of conversation. The participants also indicated academic advantages such as the accessibility of learning materials, teacher availability, and continued learning beyond class hours.

2.5.2.1.2 Compatibility

When a teacher works effectively with ICT and observes that this innovation encounters their attributes, culture, and requirements, the teacher who grew up with technology such as social media and WhatsApp will be more available and approachable on blog assessments. This is how consistent new technology is with the features and requirements of adopters.

2.5.2.1.3 Complexity

Even if innovation is recognized as perceived ease of use or difficulty, for example, if teachers know that they must go only a few steps to wrap up the period, they will be more likely to adopt new ICT. This is because technology is used to alleviate problems and makes things easier to access without considering the time-consuming and robust system. How difficult is the new technology to apply?

2.5.2.1.4 Trialability

To discover whether an innovation is effective or ineffective. For example, if the users (schoolteachers and learners) are allotted time to try an innovation with sufficient support, opportunities, resources, and time with new technology, this could make them feel comfortable and confident adopting new technology, even though they will enjoy the prototype. This is the extent to which innovation can go to the examination before deciding, which is a testing stage.

2.5.2.1.5 Observability

If the outcomes are observable and tangible, it is easier for others to adopt. For example, if learners show satisfaction with innovation, then the number of teachers would be more likely to adopt new technology based on learners' interaction with innovation. This is the extent to which innovation gives visible outcomes. After discussing these five behavioural categories, Rogers discussed five types of innovation adopters in the following section.

2.5.2.2 Limitations of Diffusion of Innovation Model

This is the oldest model, developed in 1962 with numerous limitations, which include the following:

a. The evidence regarding this theory has adopters' categories that do not originate in public health.
b. Not developed to apply in health ideas.
c. It does not encourage users to use it in health programs.
d. It works better in behavioural intention rather than precluding behavioural intention.

So, this theory has been applied successfully in many studies, including education, agriculture, communication, and marketing. It is declared that DOI is not usually used in public health; hence, it is used to facilitate the public health program aimed at changing health systems' behavioural intentions.

2.5.3 Innovation adopters' behavioural categories

The basis for adopters is innovativeness. This is where an individual relatively easily understands new ideas of a new system compared to other adapters. Innovativeness is regarded as 'relative' in that solitary adopters have higher or lower it than others in a new technology or information system (Rogers 2003). Rogers (2003) identified the five types of innovation adopters. These innovators are grouped accordingly: innovators, early adopters, early majority, late majority, and laggards.

A. **Innovators**, this cluster of users is sitting at 2.5% who adopt innovation. These groups of adopters are recognized as ventures that are comfortable with uncertainty and are reluctant to accept any challenges when innovation is ineffective. Even so, they are risk-takers (Sartipi 2020). For Rogers (2003), innovators are reluctant to experience ideal ideas. Thus, they should be aware of unsuccessful innovation and unsure of new ideas as they work as prototypes. In addition, Rogers (2003) added that these are the 'gatekeepers' who usually introduce new ideas inside and outside of the information technology (IT) or information systems (IS). They like to be the first innovation users, are keen on innovation, and are risk-takers. In short, if anything needs to be conducted, invite these people.

B. **Early adopters**, this cluster of users, sits at 13.5% of the population who adopt new technology after the developers. These types of users are highly recognizable and respected by their peers, who will ask them for advice and information on how to use new technology. Their quick response to new technology can be seen as leaders who played an important role in adopting new technology; they can be seen as endorsement letters with references for adopting new technology at the early stage. Early adopters normally like to be consulted by essential innovation (Sartipi 2020). These adopters enjoy changes; they are aware of changes that might happen with new technology and usually do not need ideas to be persuaded.

C. **Early majority**, this cluster of users is sitting at 34% of the users who adopt new technology after the developers. This group of users might plan before adopting new technology. This group of adopters usually like to participate in legitimate sources and usually delays adopting an innovation (Sartipi 2020). As mentioned, many people fear integrating, using, and adopting IT/IS (Aruleba and Jere 2022; Kruger and Steyn 2024). These people need evidence before they begin interaction with innovation, and they need an average person to start before interacting with new technology. Usually, it relies on references to see that innovation has worked before. To convince this group of adopters, a successful story might be embraced and shown evidence of innovation effectiveness. Without evidence, these clusters could not adopt ICT.

D. **Late majority**, this cluster consists of 34%, identical to an early majority group. This segment has relatively limited resources, and their doubts must be addressed before they interact with new technology. This typical group of users is highly motivated by peer pressure to adopt new ideas from innovators. These adapters are usually doubtful and conscious (Sartipi 2020). Adopt innovation after it has been used or attempted by other users or tried by the majority of users. The strategies to convince these groups include previous information on how many people have been involved in this

innovation and have adopted it successfully. Without this, these populations could not adopt innovation.

E. **Laggards**, this is the last group of users identified by Rogers (2003) with 16%. This cluster of users doubts new technology and refuses to acknowledge change. The amount of time taken to embrace new technology is long. The reason for that is that they have limited resources and want to be assured the new technology being introduced will work before any adoption (Goh and Sigala 2020). It is very important to bear in mind that only a few users (teachers and learners) will adopt new technology before the adoption curve increases sharply to the largest until the learners in rural secondary schools adopt the innovation. This group of adopters is usually slow to adopt innovation and has financial issues, not reluctance to adopt changes (Sartipi 2020). They are suspicious of change and sophisticated to approach them. So, to convince this group, statistics and pressure from other groups should be displayed.

This curve shape of the adoption is the so-called S-shaped curve adoption (Rogers 2003). This sharp point is crucial as it marks the moment when enough individuals in a system have adopted an innovation for its rate of adoption to become self-sustaining (Rogers 2003). When the critical mass stage is not achieved, innovation is not adopted, and change does not occur.

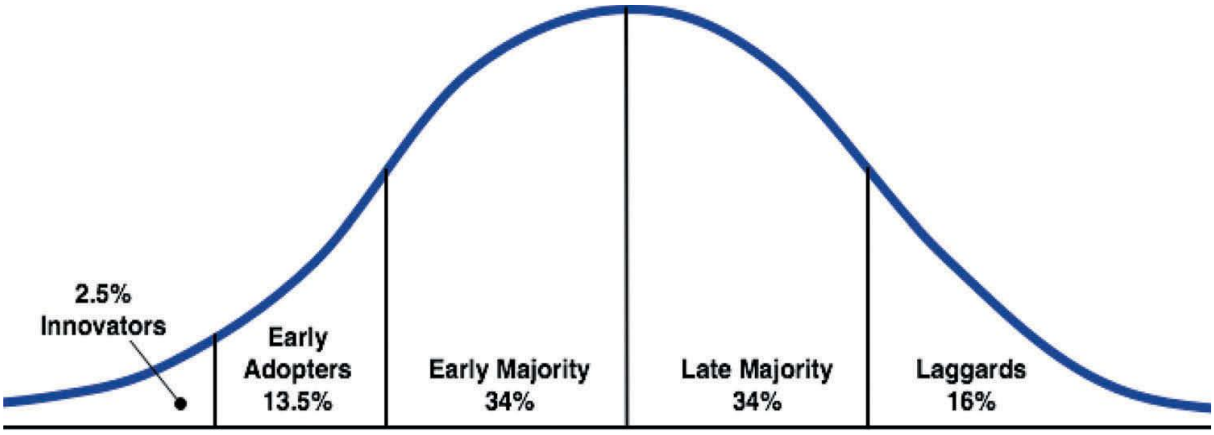

Figure 2.3: Different categories of adopters reported by (Rogers 2003)

2.5.4 Task Technology Fit (TTF)

The Task-Technology Fit Model was developed by (Goodhue and Thompson 1995). The reason for this TTF model was to create a transparent understanding of the cooperation between individual performance and IS. Task technology fit is a theoretical model that is used to evaluate how technology improves user performance. Goodhue and Thompson further described that individuals use technology as a tool for performing tasks. In addition, tasks are any action performed by individuals to convert input data into output results. Task characteristics comprised of diversity, difficulty, and interdependence may connect to an individual's dependency on using ICT

technologies; also, if individuals realize that the technology is helpful, they will notice that the technology is a pivotal tool to rely on even if they are not computerized technology is pivotal for its positive outcomes. However, if the user realizes this, technology is not helpful and simple, and the user cannot be entertained by technology.

Effective use of information technology is based on the task-technology fit model, which speculates that users will only adopt IT if the functions available to them are aligned with their activities and demands. Logical and experienced users will opt for tools and methods that provide them with the maximum net benefit and enable them to complete the task efficiently. On the other hand, information technology that does not provide enough benefits will be disregarded. The TTF model examines how technology impacts performance. Moreover, the TTF model measures how well the technology used matches the task requirements (Vanduhe, Nat and Hasan 2020). It aims to explain the utilization of technology by examining how well it fits users' tasks and requirements. The theory was introduced to enhance the understanding of technology use in both private and public contexts, but it had limited explanation on how technology acceptance contributes to individuals' performance.

The TTF was the first theory to explore the post-adoption aspect of technology utilization, unlike previous studies that mainly focused on the antecedents of use and intention (Goodhue and Thompson 1995). Specifically, by 1995, the literature on the information systems management domain was characterized by two research streams: one focused on technology utilization and the other on task-technology fit. The research on technology utilization has mainly focused on the relationships between attitudes, beliefs, and their associated factors with the use of information and communication technologies (Goodhue and Thompson 1995). This stream was represented by many theories, for example, the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and the technology acceptance model (Fishbein and Ajzen 1975; Davis 1989).

Despite these models, TAM-UTAUT participated in this study, discussing the task-technology fit (TTF) model, which is significant in disclosing the ‘fit’ of technology adoption in rural secondary schools. D'Ambra, Wilson and Akter (2013) used TTF to investigate the fit of technology and described 'fit' as a 'fit of technology tasks as well as performance'. This study has decided to use task-technology fit to validate that technology adoption can 'fit' among rural secondary schools in developing countries. Therefore, it is the best way to identify factors that might militate technology adoption (TA) in the educational domain, specifically in developing countries. Suppose TA is not appropriate among rural secondary learners. In that case, it is best to encourage other researchers to probe and apply different methods that could fit technology adoption among learners in developing countries and apply TTF. These two models provide a paramount theoretical basis for investigating the factors that affect the use, integration, and adoption of IS/IT. They provide different results; TAM focuses on attitude in the use of IS/IT in which users-based perceived use and perceived ease of use of IS/IT, while TTF focuses on user tasks needs and the availability of IS/IT.

Using TTF, TAM, DOI, and UTAUT models has indistinguishable ICT use and adoption objectives. Often, models focus on technology acceptance model by users (Granić and Marangunić 2019; Aburbeian, Owda and Owda 2022; Davis, Granić and Marangunić 2023). So, in this study, TTF focuses on adopting ICT in developing countries. For example, investigating technology acceptance feasibility via the Theory of Reasoned Action and Theory of Planned Behavior: attitude, subjective norm, and perceived behavioural control effects (Fishbein and Ajzen 1975). As mentioned, TAM examines the core constructs of perceived usefulness and ease of use to explain and predict technology use and behavioural intention (Venkatesh *et al.* 2003). Task-technology fit refers to the interdependence between technology users, technology (data, ICT infrastructure, and the services they provide), and task characteristics, which refer to the activities carried out by individuals to produce the required output. Task-technology fit comprises five constructs that represent the model (for example, task characteristics, technology characteristics, task-technology fit, technology utilization, and performance impact). Other studies reported that the TTF model comprises four constructs (for example, task characteristics, technology characteristics, performance impacts, and technology use) (Dishaw, Strong and Bandy 2002; Ratnasari *et al.* 2021). Task and Technology Characteristics affect Task-Technology Fit which affects performance or utilization (Dishaw, Strong and Bandy 2002).

Notwithstanding the identification of these constructs, other factors have been reported as major factors influencing TTF model performance. For example, 'task characteristics, then individual characteristics, and technology characteristics' (Ratnasari *et al.*, 2021). According to Goodhue and Thompson (1995); (Wan, Xie and Shu 2020), two elements influencing the TTF model are task characteristics and technology characteristics is pivotal to bear in mind these two factors reported by (Goodhue and Thompson 1995; Wan, Xie and Shu 2020) are the key factors affecting the TTF model. In this sense, all arrows point directly to the TTF model. Hence, this shows that task and technology characteristics are the foundation of TTF, which turns into performance impacts. Performance impacts are described as the achievements of a set of tasks by the user. So, if task and technology characteristics are impacted, performance impacts cannot be achieved for tasks performed by an individual. As reported by Shih and Chen (2013) economic researchers have reported on performance impacts that result from the TTF model- which happens when technology gives required elements and supports that 'fit' the task needs. Sinha *et al.* (2019) proposed an Internet of Things (IoT) solution for planning rescue operations during natural disasters. Hence, the TTF approach is used to validate the proposed solution for IoT adoption in disaster management. Furthermore, Sinha *et al.* (2019) in disaster management, the research used the basic TTF model proposed by (Goodhue and Thompson 1995).

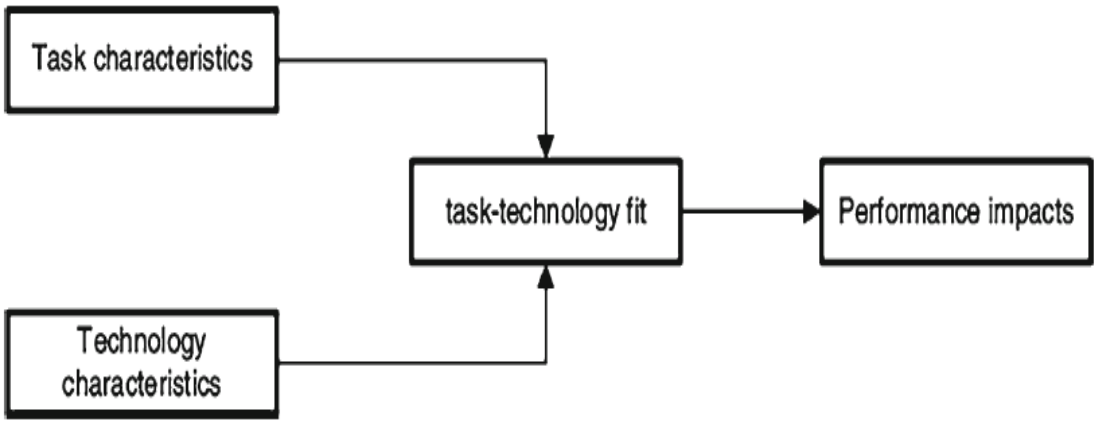

Figure 2.4: Task-Technology Fit Model (Source → Goodhue and Thompson 1995)

The general task-technology fit factor captures individuals' perceptions of task-technology fit, while task and technology characteristics reflect the specific dimensions of technology and its utilization. The TTF model proposes that task and technology characteristics influence the user's evaluation of task-technology fit. Users' rating of eight dimensions measures the level of assistance a system provides to an individual in performing their portfolio of tasks. These dimensions comprise quality, authorization, compatibility, production timeliness, system reliability, ease of use and training, and the relationship with users. Task non-routineness, interdependence, and job title are the key factors that determine the characteristics of a task. Learners may rely heavily on certain aspects of information technology due to various factors. The first proposition of the theory asserts that individuals' utilization of information systems is contingent on perceived fitness. The second proposition of this theory states that a positive match between tasks and technology predicts utilization and positively influences perceived performance, which is the accomplishment of a portfolio of tasks by an individual (Goodhue and Thompson 1995).

The development of a framework for the TTF model in this study is the consideration of vital values. The task technology fit model provides a theoretical framework to consider various issues related to technology performance. Firstly, the TTF model offers a theoretical framework that helps evaluate multiple problems related to technology performance. These issues include measuring the success of technology adoption, exploring the significance of individuals' engagement with technology and its impact on performance, and identifying the challenges associated with the use of technology in rural secondary schools. Secondly, the TTF model provides insight into the impact of technology fit and utilization on performance. It demonstrates that 14% of the difference in perceived performance is attributed to TTF, while only 4% is attributed to utilization. Thirdly, by analyzing TTF dimensions, we can improve user experience and system reliability (Goodhue and Thompson 1995).

2.5.4.1 Benefits of Task Technology Fit (TTF) Model

Task technology fit is employed to examine student performance in the adoption of technology in far-flung rural secondary schools. Also, determines the factors that affect technology adoption and competency examination. In this section, the researcher determines numerous advantages of the TTF model to examine learners' performance in developing countries. TTF, which stands for Task-Technology Fit, positively impacts the perceived ease of use of technology. In addition, the TTF Model positively influences PU (Ratnasari *et al.* 2021). Not acquainted with this implication, perceived ease of use are the determinants of attitude toward the use of technology, which predict behavioural intention and actual use Davis, Bagozzi and Warshaw (1989) in the technology acceptance model.

This study reported health challenges as the major factor affecting the wide adoption of technology among rural secondary learners in developing countries. Even a study by Shahbaz *et al.* (2019) suggests that the credentials of the technology acceptance model and task-technology fit significantly contribute to enhancing behavioural intentions to use big data analytics in healthcare. However, the TTF model analyses problems associated with using ICT to complete tasks. This means implementing tasks with accuracy, and IT support enhances employee performance (Tahar *et al.* 2020). Furthermore, the adoption of information technology can be improved by using both the TAM and TTF. In 1995, Goodhue and Thompson proposed the TTF, which expands upon the TAM by examining the impact of task technology use (Tam and Oliveira 2016). It is crucial to use the extended model to improve technology acceptance. This study has decided to adopt an extended model for better improvement of ICT adoption; this is done to meet the objective of the study. The following section discusses the drawbacks of TTF in the adoption of technology.

2.5.4.2 Barriers of Task Technology Fit (TTF) Model

The growing use of social media platforms among learners has led researchers to study their willingness to participate in social media and the impact of its usage in an educational setting. Learners inevitably use social media at school; even off school, they utilize it to share information. Even so, the TTF model significantly negatively impacts the relationship between social media use and its outcomes (Sabah and Altalbe 2022).

Wan, Xie and Shu (2020) combined the UTAUT and TTF to discuss the intention to use massive open online courses (MOOC). The limitation of the TTF model in predicting characters proved that it may not consider the important factors in social aspects of continued usage intention. Also, the TTF-UTAUT model has been condemned due to a deficiency in focusing on factors that can structure the adoption of users (Marikyan and Papagiannidis 2023).

Social influence examines the impact of external factors on an individual’s decision to adopt technology. It includes factors such as peer pressure, social norms, and support from colleagues or superiors even though TTF may not emphasize the prominence of social influence.

The TTF model tries to solve the drawbacks of TAM to understand the usability of technologies (Dishaw and Strong 1999). The drawback is the deficiency of focus on the task since IT is the tool learners use to do their tasks at and after school. This drawback contributed to the differences in the results of information technology examinations (Goodhue and Thompson 1995). Moreover, the TTF model has been condemned by a deficiency of focus on user psychological and situational factors, for example, the key role of top management, trust, and the duties of team members (Agarwal, Sambamurthy and Stair 2000).

2.5.5 Unified Theory of Acceptance and Use of Technology (UTAUT) Model

Often theoretical models, for example, TRA developed by (Fishbein and Ajzen 1975), Theory of Planned Behavior (TPB) developed by (Ajzen 1991), the TAM developed by (Davis 1989), the Motivational Model (MM) developed by (Davis, Bagozzi and Warshaw 1992), the Innovation Diffusion Theory (IDT) developed by (Rogers 1995) and many more were developed to measure the actual use (AU) of technology or systems and or apps. So, this study measures technology adoption among learners in developing countries. The UTAUT being used in previous studies heightened and explains almost 70 per cent of the variation with a common variable included, which are so-called exogenous variables, for example, Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and the Facilitating Condition (FC) (Venkatesh *et al.* 2003). It has two endogenous variables, for example, Behavioral Intention (BI) and use behaviour (USE), which improve the above-mentioned models by explaining almost 30% to 40% of the disparity (Venkatesh *et al.* 2003). Therefore, this study excludes these two endogenous variables in a new proposed framework.

Behavioural intention measures the likelihood of a user (learners) applying technology. Therefore, it is pivotal to understand the factors affecting the behavioural intention to improve technology training (Davis, Bagozzi and Warshaw 1992). Actual use (AU) occurs before performance expectancy, effort expectancy, social influence, and facilitating conditions. So, in this regard, the UTAUT becomes the lens to address the issue related to the attitude toward adopting technology to adopting five major factors from the principal component analysis. This model UTAUT could underpin the study to verify whether over-digitalization of education, cognitive barriers, health challenges, time constraints, and funding affect the widespread adoption of ICT among learners in rural secondary schools in developing countries. Based on this, the development of the UTAUT model can specifically rely on the contexts of ICT adoption to rectify the investigation of how internal and external variables affect Technology Adoption. This study investigates factors that affect the wide adoption of technology among secondary learners in developing countries based on the UTAUT. To bridge the gap between two separate areas of research, the DOI theory was created. It aimed to merge evidence from both fields and investigate the assumption that the use of technology leads to better performance, provided that the technology's functionality aligns with the users' task requirements. Many researchers have decided to develop their conceptual framework. The following section discusses the UTAUT variables.

The UTAUT model, developed by Venkatesh *et al.* (2003), identifies performance expectancy, effort expectancy, social influence, and facilitating conditions as determinants of behavioural intention and use behaviour (see Figure. 2.5).

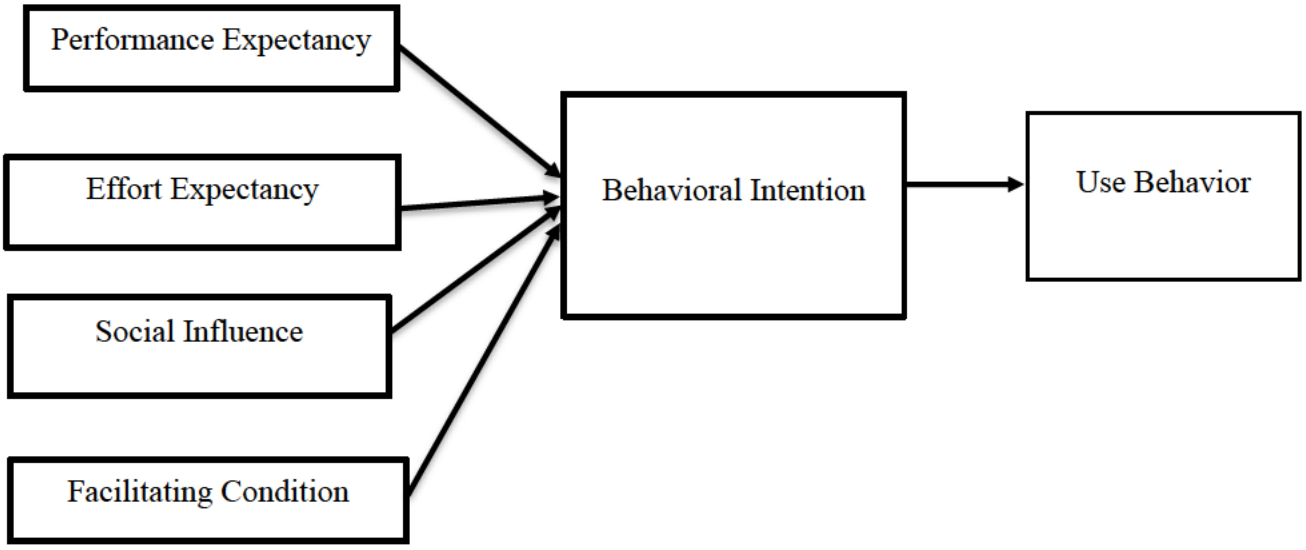

Figure 2.5: The Unified Theory of Acceptance And Use of Technology (UTAUT) model Source →Venkatesh *et al.* (2003)

2.5.5.1 Benefits of the Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT model has advantages (Lee and Rho 2013). The UTAUT model explained 69% of information technology use intention, while other models explained only 40% of technology acceptance. According to Venkatesh *et al.* (2003), the UTAUT model is a more credible theory compared to others as it has a higher explanatory power, which can justify 70% of the variance in the behavioural intention construct. In addition, the UTAUT model was created by incorporating eight existing models: the theory of research action (TRA), TAM, the motivational model (MM), the theory of planned behaviour (TPB), a combination of technology acceptance model and the theory of planned behaviour, the model of principal component utilization, the innovation diffusion theory (IDT), and social cognitive theory. All models have pros and cons, but the UTAUT model effectively measures technology acceptance (TA) across domains (Venkatesh *et al.* 2003; Chao 2019; Jevsikova *et al.* 2021; Wijaya *et al.* 2022). Users have often been compelled to immediately adopt and use a specific technology to adapt to the new reality. The UTAUT model is frequently used to explain technology adoption in organizations and individuals (Chao 2019; Venkatesh 2022). In this study, the UTAUT model is used to measure factors affecting the wide adoption of ICT in rural secondary schools in developing countries. The UTAUT model has been widely adopted as a model for technology acceptance (TA) in both organizational and non-

organizational contexts (Tamilmani *et al.* 2019). Thus, the primary goal of this study was to identify the key factors affecting learners' adoption of ICT. This model is recommended as one of the best models to identify factors influencing the adoption of information and communication technology. The reason for this, the UTAUT model is effective in measuring tech acceptance across domains (Venkatesh *et al.* 2003; Chao 2019; Jevsikova *et al.* 2021; Wijaya *et al.* 2022).

2.5.5.2 Barriers of the Unified Theory of Acceptance and Use of Technology (UTAUT)

Many studies apply the UTAUT model in the acceptance of technology in public and private enterprises. Despite applying the UTAUT model, studies often add new variables to solve the problems. This is because the UTAUT model does not meet the desired aims of technology acceptance, which is why many studies construct new components. Oh and Yoon (2014), in predicting the use of online information services based on the UTAUT model, added two constructs to the UTAUT. The findings suggested that the proposed model can better explain the behavioural intention towards internet services than the UTAUT model. Abdulwahab and Dahalin (2021), in their research on learning management systems during the coronavirus disease, employed an extended UTAUT model.

Although the UTAUT model has its advantages, it also has some drawbacks. Notably, this model fails to account for crucial factors such as attitude, anxiety, and self-efficacy, which are natural components of intention. Moreover, attitude toward technology use does not necessarily directly influence intentions (Raza *et al.* 2021). Anxiety Venkatesh *et al.* (2003) describe anxiety in this way: when it comes to using technology, technophobia is the fear or anxiety an individual experiences. Empirical evidence from the study by Abdulwahab and Dahalin (2021), respondents reported, “I feel nervous about using ICT facilities in Telecentre, and It scares me to use ICTs in Telecentre because I lack adequate skills.” The study reported a deficiency in ICT skills. Based on the disentanglement or drawbacks of the crucial factors mentioned above this study has decided not to apply the natural UTAUT model, instead developing a new framework with supplementary components reported from the principal component analysis diagram in Dimension 1, these components are over-digitalization of education, funding, health challenges, cognitive barriers and time constraints. This is underpinned by the study of examining factors affecting the adoption of blockchain technology, the suggested model has strong explanatory power and is reliable in various situations, as shown by this study's findings (Jena 2022).

The UTAUT model can be uncompromised if it is applied in heterogeneous settings. For example, low explanatory power arises when explaining the variance of users' behaviour in non-Western contexts. In 2007, Al-Gahtani and colleagues applied the UTAUT model to a non-Western culture, specifically the Kingdom of Saudi Arabia. Their findings revealed that UTAUT could account for only 39.1% of the variability in the behavioural intention construct and 42.2% in the usage construct. Additionally, the two main determinants of facilitating condition and effort expectancy in UTAUT did not significantly impact the behavioural intention toward the use of IT. Other studies have also found UTAUT to have lower explanatory power, such as 64.5% (Wang and Shih

2009), 35.3% without moderation, and 39.1% with moderation (Teo 2011). Therefore, applying UTAUT to increase exploratory power does not guarantee high predictability or explained variance in BI across settings and cultures.

Nevertheless, the UTAUT may not always apply to alternative settings due to differences in the relationship (Thomas, Singh and Gaffar 2013). Moreover, the UTAUT exhibits low parsimony because of the intricate connections among its constructs, as evidenced by multiple effects and moderations (Venkatesh, Thong and Xu 2016). Although UTAUT integrates eight well-known theories, it still has limitations and cannot solve all the weaknesses of previous theories (Alshammari and Rosli 2020). In addition, UTAUT needs modification to be applied to some applications like mobile commerce (m-commerce) because it is not perfect in m-commerce (Venkatesh *et al.* 2003).

Therefore, this study could not adopt the original UTAUT model; based on the factors reported by previous studies in the literature, the study could add construct factors from the PCA diagram in Dimension 1 to measure the factors affecting the wide adoption among learners in rural secondary schools in developing countries. In addition, this study reported the top five factors that have affected the adoption of ICT in developing countries: over-digitalization of education, funding, cognitive barriers, health challenges, and time. However, the UTAUT model could be extended with the abovementioned top five factors. The UTAUT model integrates eight prominent theories but still has limitations and cannot solve all weaknesses (Alshammari and Rosli 2020). The contextual factors are grouped as external and internal factors in a study framework.

2.6 The role of ICT in the classroom

This section unpacks the role of ICT in the classroom for the teaching and learning process. In this role, ICT is an enabler, not a driver of the teaching and learning process; it makes it easier to commence pedagogy and studies since it acts as a catalyst to alleviate problems (Zhang, Gong and Zhang 2022). The use of ICT requires an extensive application of skills. This section develops a demonstration of ICT use in the classroom to expand the importance of its traits in modern education.

The trend of ICT in education is superb; in essence, it is leading the Department of Basic Education (DBEd) to disseminate digital tools such as (interactive whiteboards, projectors, tables, internet, network (Wi-Fi), desktops, computers, laptops) and so on to ensure that rural communities are not left behind the technology. However, extant literature shows that teachers and learners lack the digital skills needed to apply technology, which limits their use of technology; it also can hurt learners learning and can create inequalities in education, specifically in the Sub-Saharan regions (Enrique Hinostroza 2018) . As mentioned above, teachers and learners lack ICT skills, and this dilemma seems to have an abundant role in developing countries.

A conducted study of Education 5.0 focused on developed and developing countries showed that developing countries continue the trend to lag in Education 5.0 (Zimbabwe and Sri Lanka); by contrast, developed countries (Saudi Arabia and Malaysia) Education 5.0 have implemented

effective (Alharbi 2023) while Sub-Saharan regions are ineffective. Regardless of these tools stated above (interactive whiteboard, projector, tables, internet, network (Wi-Fi), desktop computers, laptops) operating as a pillar of technology in the classroom, the ideal innovation of focusing on Education 5.0 is pivotal to focus on modern technology for example Artificial Intelligence (AI), robotics, and machine learning.
Learners normally use wireless networks (Wi-Fi) to connect laptops, tablets, and smartphones inside and outside classrooms; even at home, they use wireless connection because it is affordable compared to fibre. Some networks, such as fibre, Asymmetric Digital Subscriber Lines (ADSL), and routers, are unaffordable to install at home. Huerta *et al.* (2023) results indicated that the supply of network (Wi-Fi) with open-access coverage would produce favourable results, such as reducing poverty and improving dwellers' lives.

Moreover, installing a network (Wi-Fi) can offer long-term support for dwellers and learners to support economic development, allow accessibility to 'educational resources,' perceived ease of communication, and support practice (Huerta *et al.* 2023). Based on this, installing wireless networks can support the implementation of ICT inside and outside the classroom.

Figure 2.6, this is to explain the role of Information and Communication Technology (ICT) in the classroom with a task projector, interactive whiteboard (IWB), webcam, desktop computer (PC_1) switch, remote controller, smartphone and Wi-Fi (network) zone. The projector is connected to the wireless for display, IWB is connected to the Wi-Fi, while the webcam is used for teachers or learners for an online assessment, PC_1 is compatible with the webcam and connected to the switch with an IP (internet protocol) address. A learner or teacher can use a remote controller to turn on IWB, a learner or teacher can use IWB as well, and the learners can utilize a smartphone to connect wirelessly. The learner can enter the login details to prevent fraud. In technology, security is extremely crucial to circumnavigate information theft. On the other hand, learners can fail to connect to the network due to the lack of Wi-Fi (network) connectivity. According to Belay (2020), in "poor countries like Ethiopia, students lack internet connections at all, particularly in rural areas".

The adoption of these devices can play a vital role in the classroom and can transform the teaching and learning process in many ways, for example, can improve learning material, interactive learning, personalized learning, collaboration, quick feedback, ICT skills development, access to the world perspectives, motivation and engagement. All together, ICT in the classroom can create a more dynamic, inclusive, and effective learning environment, preparing learners for a technologically advanced world.

If these devices can be applied in the classroom, rural secondary school learners can improve more in technology. Further, providing these tools can contribute toward the improvement of educational levels in rural schools. So, it is the best advice for the Department of Basic Education (DBEd) to ensure the ubiquitous of these devices in the classrooms.

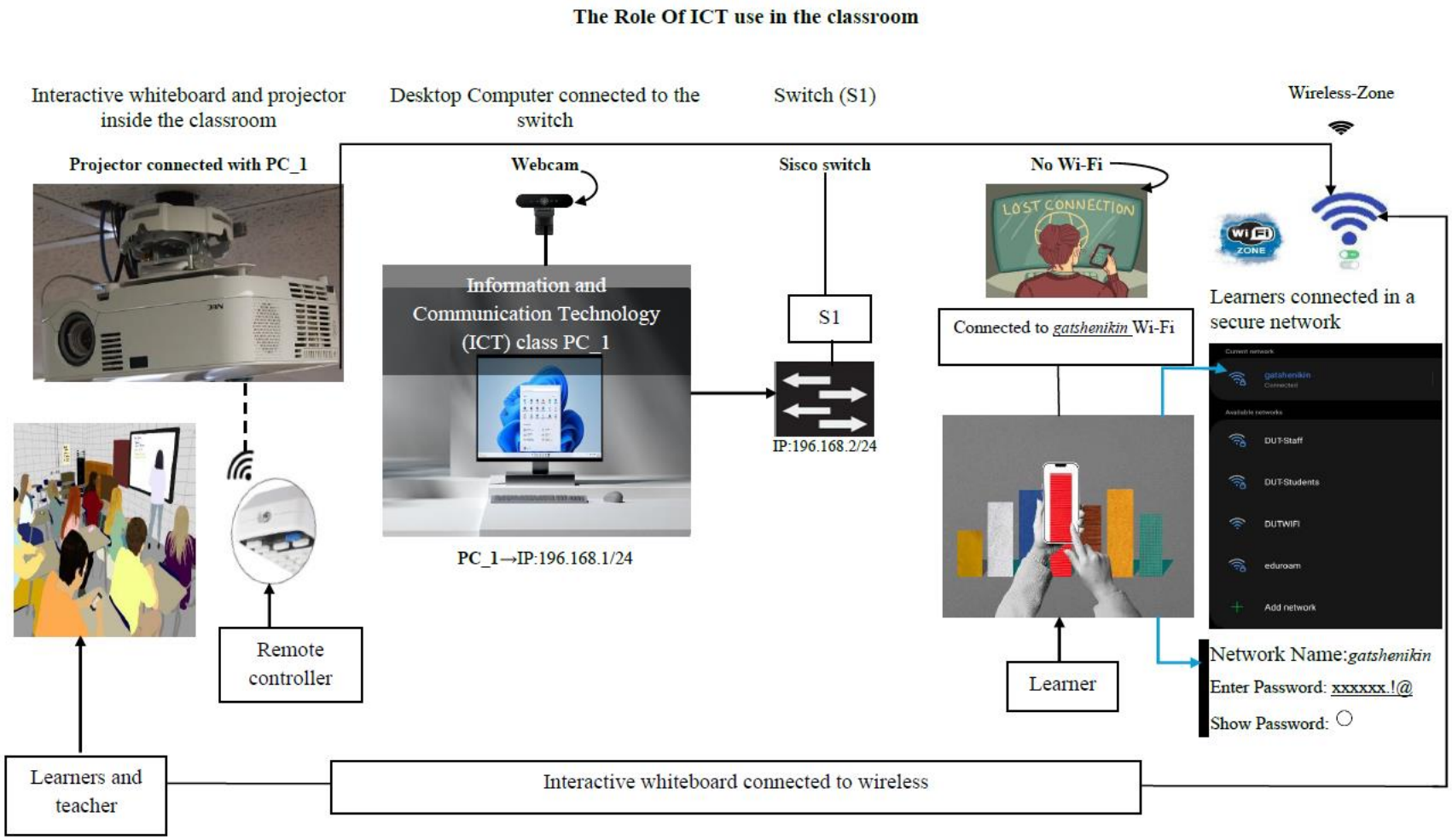

Figure 2.6: The role of ICT in the classroom

2.7 Teacher and parent influence

Teachers and parents influence ICT adoption among learners in developing countries. The COVID-19 coronavirus pandemic and the fourth industrial revolution customized human beliefs and developed different notions in our lives. This transformation created numerous disbeliefs in the educational sector. Moreover, teachers and parents have different perspectives on online learning. According to Basar *et al.* (2021), online learning is not practical; this refers to the lack of collaboration among parents to support learners. Specifically, for learners receiving teacher and parent stimulation to learn and use the internet for research, their self-learning is associated with digital innovation. For those without teacher and parent stimulation, self-learning is associated with lower chances of digital innovation. Digital innovation can be cultivated by addressing the perceived use of online learning on the internet and encouraging teachers and parents to influence learners to adopt ICT.

Previous studies discussed the lack of ICT skills and support in previous studies, and these challenges were reported in this study. Afshari *et al.* (2009) investigated factors affecting teachers' use of ICT and discussed parent and community support. Their discussions include the following:

a. Network supports both learners and parents to learn ICT together,
b. Skills development for parent or adult courses,
c. The supply of crèche to support parental access.

In addition, the support of parents "can influence the implementation of ICT in education." It is recommended that parents be supported with ICT resources; this could enable them to collaborate with children after school, and this could aid learners in interacting with parents and becoming acquainted with ICT. Skills development is essential, and creating adult courses could help parents familiarize themselves with information and communication technology. Providing a crèche with ICT infrastructure can reduce the lack of ICT skills and augment access to ICT. These are the three values influencing parents in the adoption of ICT, including the lack of essential equipment, such as ICT infrastructure.

There are many factors which affect the adoption of ICT. Buabeng-Andoh (2012) reported many factors (barriers) have a positive and negative effect on the teaching and learning process; these factors are grouped into different levels:

1. **Personal** level refers to (feelings, knowledge, and attitudes). Buabeng-Andoh (2012) suggests that if teachers can provide a positive attitude, educational technology can be easily successful, and the use of ICT technology and educational technology can be easily successful with better insight into ICT integration in the teaching and learning process.
2. **Teacher** level refers to (lack of teacher ICT skills, lack of teacher confidence, lack of teacher ICT training, and lack of teacher training projects). Teachers' professional

development is a desired tool in the integration of Information and Communication Technology (ICT). Most teachers need development with professional skills that meet educational technology requirements. The ongoing challenges of ICT skills are often reported in studies. For example, Atman Uslu and Usluel (2019) developed two types of skills. for example, “basic competence” and “advanced competence.” The reason for this was to resolve ICT skills challenges. Ntalindwa *et al.* (2019); Jogezai, Baloch and Ismail (2020); Seifu (2020) reported that motivation in schools is a significant challenge affecting teachers. Information and communication technology training motivates teachers to use technology.

3. **School** level refers to (lack of ICT infrastructure, funding, support, ICT training, old hardware, lack of modern software, lack of access to ICT, and lack of ICT mainstreaming into schools). Previous studies reported these challenges; this is a reference by Lawrence and Tar (2018) in a discussion with the teacher in the investigation of factors that influence teachers’ adoption and integration of ICT; the teacher reported technical issues related to limited ICT infrastructure as a barrier hindering the wide use of ICT in teaching. Moreover, 'in developing countries like Nigeria, electricity blackout is quite regular and computer accessories such as projector will snap off due to constant power outage. Internet connectivity is another huge problem; the internet connection is not stable and very slow when it is on, and most of the time there is no connection.' This is in line with Mihai (2017); (Bester *et al.* 2021) reports on electricity interruption in developing countries.

4. **Systems-level** refers to (limited organizational plan, traditional assessment, restrictive curricula, and 'rigid structure of traditional education systems'). Traditional education needs to change to meet modern educational technology. This is confirmed by the Bankmycell (2024) reports that in 2023, a more significant number of people will use smartphones around the globe. However, the increase in smartphone users shows that pedagogical culture has already changed to educational technology, and traditional education systems seem outdated.

In addition, this research also reveals other inhibited barriers to using ICT, for example, small classes, lack of training, deficiency of technical and pedagogical support, lack of motivation, poor leadership, and lack of collaboration. Even though studies have often reported these challenges, it is recommended that government agencies and policymakers address the ongoing challenges.

2.8 ICT adoption factors

Afshari *et al.* (2009) state that one of the predominant challenges facing developing countries is making technology a prerequisite part of people's culture. Information and communication technology is recommended to transform cultural and traditional education into educational technology. This transformation has been recognized as a change in human culture and behaviour

around the globe. The heavy invention of ICT influences societies since learners are often required to apply digital technologies to adopt ICT at schools. One key factor that gained much growth and access in modern educational technology is the perceived use (PU) of mobile phones with perceived ease of use (PEU). Despite perceived use and perceived ease of use, rural schools and societies in developing countries struggle to acquire access due to the barriers claimed in this study. The state pervasiveness of information and communication technology is recognized as the best platform and feature of communication globally, as is the cultural practice of literacy. The approximate population growth of smartphone users increased from 49% in 2016 to 83% last year (2022) (Bankmycell 2024). In addition, in 2023, smartphone users in the globe today are sitting at 6.92 billion, meaning that only 85.95% of the world's population owns smartphones. The high number of PU smartphones shows that human cultural and pedagogical culture has transformed traditional education into modern education based on the abovementioned figures.

2.8.1 Culture

Refers to the behaviour, beliefs, and habits of the local communities and rural schools in developing countries. For example, if someone plans to buy a computer, they find it difficult to trust anyone and get advice on which machine is recommended. The lack of ICT skills causes this; what is missing is a professional IT specialist who will advise teachers and learners in rural schools and be acknowledged as a professional expert in ICT. Khalid, Islam and Nyvang (2013) local investors trust the change agency to assist the local community in rural areas in buying computers. Therefore, it is a wise dream to allow the change agency to spend more time in rural schools to stimulate change in culture by providing knowledge.

Chen, Lu and Okawa (2023) proposed a model to change the formal approach in secondary school, allowing learners to develop global skills and communicate with diverse cultures via ICT tools. However, this model includes settings to connect with local society members and simultaneously with the facilitator society. Hence, the implementation of this model shows that culture is a major factor that affects learners' participation.

2.8.2 Government policies and initiatives

The information and Communication Technology sector has proven to be the predominant sector in education in both developed and undeveloped countries; this has caused many dramatic changes in countries to integrate, adopt, and use ICT in the educational sector and lured other researchers to investigate heavily in ICT integration, adoption, usability, and challenges. Moreover, in industries such as the economy, mining, health, security, banking, agriculture, etc. Despite the high contributions of ICT in the educational sector among rural schools in developing countries, this sector needs integration and adaptation in the fourth industrial revolution. Adapting and transforming this will create new challenges in rural schools, which means that the government decisions will be changed to meet educational modernization due to the unplanned difficulties encountered in introducing the fourth industrial revolution and educational modernization. These changes are supported by the introduction of the (COVID-19) coronavirus pandemic; during the

pandemic, the global government forced the teaching and learning process to be conducted online (eLearning) to mitigate the spread of the virus. Despite these transitions, developing countries were suffering the most due to the lack of ICT infrastructure (Mhlana, Chipangura and Twinomurinzi 2021; Mahlo and Waghid 2022; Ssenyonga *et al.* 2022; Sulistiyo *et al.* 2022; Teye and Duah 2022; Van Greunen and Fosu 2022; Gamit 2023; Matli and Phurutsi 2023; Shala and Grajcevci 2023; Zenda and Dlamini 2023).

The Electronic Transactions Act (ETA) of 2005, the Electronic Communications Act (ECA) of 2005, and the Broadband Policy gazetted by the Department of Communications regulated by the Independent Communications Authority of South Africa (ICASA) in South Africa are Acts (policies) designed to monitor the issue of *affordability*, *availability* and *accessibility* of ICT resources in the country (Hilbert 2011; Chisango and Lesame 2017; Aruleba and Jere 2022). This is in line with Kenya's ICT policy, which aims to ameliorate the society of Kenya by ensuring the *availability*, *accessibility*, *efficiency*, *reliability*, and *affordability* of ICT resources (JG, Kosgey and Sang 2012). Developing countries still face development challenges, for example, internet access (Coopasami, Knight and Pete 2017; Barnard-Ashton *et al.* 2018; Harerimana and Mtshali 2018; Madida, Naidoo and Rugbeer 2019; Chisango *et al.* 2020), high cost of data bundles and technology devices (Bester *et al.* 2021), inhibits the adoption of ICT in rural schools, and lack of ICT infrastructure (Aruleba and Jere 2022), and electricity interruption (Mihai 2017; Bester *et al.* 2021). Even so, with the keen eye of the government, the supply of proper ICT services, for example, the supply of ICT infrastructure, broadband, and amortization of technologies in all rural schools encountering the above challenges, no doubt, some of these challenges will reduce. With no hesitation, the government knows that improving these challenges could modify socioeconomic and educational challenges and improve the quality of education in rural schools based on the supply of essential ICT services reported above (Leng *et al.* 2020). The improvement of rural education and infrastructure, for example, roads and broadband facilities, can improve the adoption of ICT in rural communities to increase the economy and quality results of education, since the policymakers fail to identify the necessity of ICT in quality education (Hossain, Hashmi and Mezbah-ul-Islam 2019). In addition, Zhang, Gong and Zhang (2022) reported that the supply of ICT resources has improved health issues and revealed that internet access and mobile phone availability can reduce the mortality rate.

Safonov, Usyk and Bazhenkov (2022) reported that the European Union (EU) developed and implemented a national digital skills plan; in countries like Ukraine, the development and implementation of digital skills the society is the foremost priority in the educational transformation, and this is essential in the development of the economy, job and ensuring the social progress among learners. In addition, today, the ambassadors of the digitalization of educational policy are the Mister of Education and Science and the Mister of Digital Transformation of Ukraine. Their objective is to improve the digital literacy of the Ukrainian population.

Based on Safonov, Usyk and Bazhenkov (2022), if the African Union (AU) can develop and implement strategies like the EU digital skills, there is no disbelief that some of these challenges

will be reduced. The Ministry of Educational Sectors should collaborate with developing countries like Ukraine Ministers to reduce factors affecting the broad adoption of ICT among rural secondary learners in developing countries as the EU performed successfully. According to (Younie 2006), five major areas usually cause problems in the implementation of government policy, for example, 'management, funding, technology procurement, ICT training and impact on pedagogy'; the analysis reported that the government policy objectives can be achieved if the government can create awareness of the complexity of the implementation.

The following table demonstrates the author/s, factors, benefits, and barriers of ICT. Extant literature discussed these challenges in ICT; in the 80s, Davis, Bagozzi and Warshaw (1989) identified electric power, poor network, lack of ICT training, cost of technologies, illegal use of mobile phones in the classroom, and unbearable noise caused by learners with cell phones in the school. These challenges persist, and Becta (2004) identified these barriers as cultural, funding, ICT infrastructure, individual, institutional, and knowledge. Not considering another study revealed support, lack of investment in ICT, lack of management planning, and lack of professionalism in the top management (Rabah 2015). As shown in Table 2.2, one column is for the benefits perceived with the orange tick (✓), and the second column is a barriers perceived with the red tick (✓).

Table 2.2: Comparison Of Perceived Benefits And Barriers Of ICT.

Author/s	Factors	Benefits	Barriers
Kenya (2005)	Support educational technology	✓	—
	Quality of Service (QoS)	✓	—
JG, Kosgey and Sang (2012)	Data improvement	✓	—
	Communication improvement	✓	
	Records management	✓	—
Mfaume (2019); Nikolopoulou (2020); Al-Ansi, Garad and Al-Ansi (2021); Kang (2021)	Motivation	✓	—
	Active engagement	✓	—
	Admired lessons	✓	—
	Accessibility	✓	—
	Learners engagement	✓	—
Becta (2004)	Cultural	—	✓
	Funding or financial barrier	—	✓
	ICT Infrastructure	—	✓
	Individual	—	✓
	Institutional	—	✓
	Knowledge	—	✓
Davis, Bagozzi and Warshaw (1989)	Electric power	—	✓
	Limited network access	—	✓
	ICT training	—	✓

	Cost	—	✓
	Mobile phone use inside the classroom	—	✓
	Unbearable noise in the classroom	—	✓
Rabah (2015)	Lack of supporting	—	✓
	Lack of investment	—	✓
	Lack of curricular planning	—	✓
	Professionalism	—	✓

2.4 Chapter Summary

This chapter discusses a comprehensive background showing information and communication technology is integrated, used, and adopted in education. Moreover, different factors were highlighted, which shows that ICT skills, ICT infrastructure, poor networks (Wi-Fi), financial barriers, and support are the prominent factors that delay technology delivery in rural areas. Also, it has been highlighted in previous studies and approaches that different models have been used to solve this problem of ICT adoption. This challenge is still progressing and is hindering the ubiquitous adoption of ICT in the Sub-Saharan regions. So, this gap motivates us to develop a new framework to mediate ICT adoption stumbling blocks. The following section discusses the methodology applied in this study.

CHAPTER 3 : RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodological framework steps to achieve the study's overall aim and objectives: a) the comprehensively review and identify factors that influence the widespread adoption of ICT among rural secondary schools from the literature, b) rank the identified factors based on their importance using Principal Component Analysis, c) to develop a framework to aid the widespread adoption of ICT among rural secondary schools, and perform a comparative analysis of the new framework's construct against the state-of-the-art ICT adoption framework. The methodological framework entails data collection, pre-processing, codification, principal component analysis, and comparative analysis. Chapter Three is structured in three sections. The first section briefly introduces the chapter, section 3.2 discusses the methodological framework of the study with its attributes, and section 3.3 summarises the chapter.

3.2. Methodological Framework

Figure 3.1 presents the methodological framework that depicts the flow diagram. The framework designed by (Ellis and Levy 2010) applied in a proposed methodology framework in the flow diagram. To design methodology frameworks, it is very important to define any concepts that will cater to the basic facts of the study, combine them into a logical link, and associate these concepts with the study. The proposed design links five steps for example (data collection, pre-processing, principal component analysis, and comparative analysis) to structure the new framework. Likewise, Ellis and Levy (2010) used six steps to guide novice researchers in a design research approach.

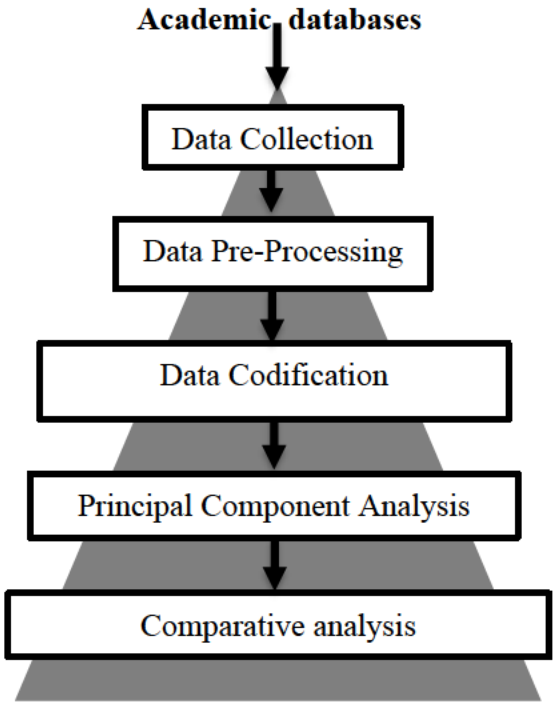

Figure 3.1: Study methodology framework

This study used a qualitative comparative analysis of existing models based on comparing the three prominent models (technology acceptance model, task technology fit, and unified theory of acceptance and use of technology models). The comparisons of these models aimed to develop a new framework. To acquire sufficient positive outcomes, 14 constructs were used to reference the contribution of each model in the development of a new framework (see Figure 4.3). However, this study used a design research approach.

This study aligns with the post-positivist research philosophy (Ryan 2006; Fox 2008). It acknowledges that while ICT adoption can be measured through objective indicators such as infrastructure availability, teacher training, and student access, it is also influenced by social, cultural, and contextual factors. Post-positivism recognizes that bias, contextual realities, and human interpretation shape ICT adoption in African secondary schools, making it necessary to critically assess and refine findings rather than assuming absolute objectivity (Silva 2007).

3.2.1 Data collection

Data collection is a significant feature of the research aims, objectives, and research. With that significance, it is necessary to elaborate on how data were gathered in this study. Hence, the dataset used in this study is secondary data collected from two prominent academic databases: Scopus and Web of Science. Data screening was conducted based on PRISMA guidelines. These guidelines are based on a readiness to upgrade the quality of systematic literature review. According to Page *et al.* (2021) PRISMA diagram was planned to assist systematic literature review in gaining transparency on the review, researchers' contribution, and output.

3.2.1.1 Search strategies

In this study, the data was collected using a search strategy using Boolean operators (AND/OR). The main aim of adopting Boolean operators was to search on Scopus and Web of Science. The search strategy was used to obtain the dataset from Scopus and Web of Science, Accessed-Date 04 May 2023, 01:35 AM. This is associated with an empirical study conducted by Aruleba and Jere (2022) in exploring digital transformation challenges in rural areas of South Africa. These two prominent academic databases have good content of information and communication technology and science journals. After selecting these two prominent academic databases, the search terms were formulated to meet the aims and objectives of this study. The different Boolean operators were exploited to amalgamate key terms that are required to be searched (see Table 3.1). All search terms were JOINED with special operators *AND/OR* to acquire all feasible studies in a search text box. The 'AND' operator narrows the search while the 'OR' expands the search. The focus, which is the main core of this study, is ICT adoption, while the rest is followed by encountering the content of this systematic literature review (SLR). Moreover, the essence of this study is a systematic and qualitative review, and the researcher follows the footsteps of the PRISMA paradigm and existing data (dataset).

Table 3.1: Search Terms Used With Boolean Operators.

Databases	**Search description**
Scopus	("ICT adopt*" OR "adopt* of ICT" OR "information communication technology adopt*" OR "ICT us*" OR "use of ICT") AND ("Rural school" OR "schools" OR "secondary school") AND "factors"
Web of Science	("ICT adopt*" OR "adopt* of ICT" OR "information communication technology adopt*" OR "ICT us*" OR "use of ICT") AND ("Rural school" OR "schools" OR "secondary school") AND "factors"

3.2.2 Data pre-processing

Data is not one hundred per cent complete. It can discard vital attributes. Moreover, data can be reiterated by sending identical messages. So, to avoid these duplications and incomplete data, this study applies a pre-processing method. Pre-processing is the process of alteration, if not extraction, of data before being included to encompass the aims and objectives and answer the study's research questions (Maharana, Mondal and Nemade 2022; Saraswat and Raj 2022). Data preprocessing is crucial to ensure the quality and consistency of the data used in subsequent analyses.

Tables 3.2 reveal that only publications that meet the research aim, objectives, and research questions are included, and papers not written in English, papers published before 31 December 2016, not reporting ICT adoption, duplicate peers, not find the full text, and do book section are excluded. Based on this, 216 are excluded since they did not meet the study's research aims, objectives, and research questions, and 228 still exist. On top of that, 144 papers were eliminated

due to the lack of study requirements.

Table 3.2: Inclusion And Exclusion Criteria.

Inclusion Criteria (IC)	
IC1	Papers written in the English language
IC2	Papers published from January 2017 to 2023
IC3	Papers identifying ICT adoption
IC4	Residing in rural areas and secondary schools
IC5	Papers researched in developing countries/regions
IC6	Papers with abstract and conclusion
IC7	Find full text (found *PDF* and *URL*)
Exclusion Criteria (EC)	
EC1	Papers not reporting in the English language.
EC2	Papers published before 2017 and after 2023.
EC3	Papers not reporting ICT adoption.
EC4	Duplicate papers.
EC5	Full text is not available.
EC6	Book selection.

Overall, 84 papers that meet the study requirement remain included. The overall papers included in this study are laid out in the final step of the PRISMA diagram in Figure 3.2. These papers are carefully read and scrutinised by following the PRISMA guidelines. So, this data could be used to form this study. The data flow of the two databases, Scopus and Web of Science, are demonstrated in Figure 3.2 for screening.

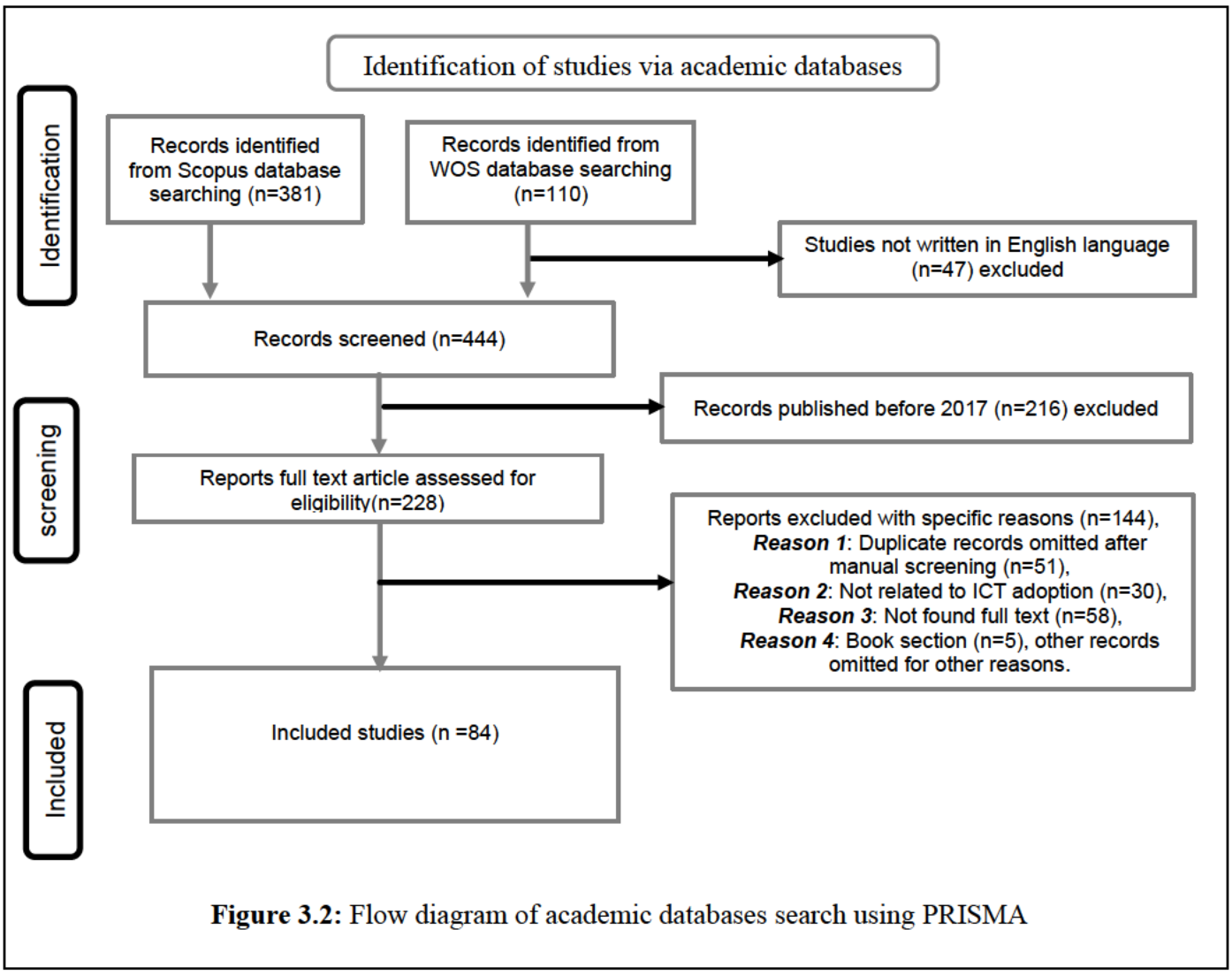

Figure 3.2: Flow diagram of academic databases search using PRISMA

After using key search terms, inclusion and exclusion criteria, and PRISMA protocol, Table 3.3 recorded all the results uncovered with three cluster factor numbers (F.No), factors, and authors with year of publication. Factors are sorted in alphabetical order.

Table 3.3: Identified Factors From Scopus And Web Of Science Databases.

F. No	Factors	Author/s and year of publication
F1	administrative	Seifu (2020)
F2	anxiety	Cussó-Calabuig, Farran and Bosch-Capblanch (2017)
F3	attitude (positive attitude)	Eickelmann, Gerick and Koop (2017); Chen *et al.* (2019); Paunova-Hubenova, Terzieva and Todorova (2019); Aljuhani *et al.* (2020); Prodani *et al.* (2020); Trujillo-Torres *et al.* (2020); Hu and Yu (2021); Pozas and Letzel (2021); Rudhumbu, Du Plessis and Mudau (2021); Sulistiyo *et al.* (2022); Teye and Duah (2022); Thannimalai *et al.* (2022); Lomos, Luyten and Tieck (2023)

F4	awareness and/or programmes and/or outreach	Xu et al. (2021)
F5	behaviour	Brenes-Monge et al. (2020)
F6	beliefs (perception or ICT self-efficacy)	Cussó-Calabuig, Farran and Bosch-Capblanch (2017); Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017); Hatlevik (2017); Uslu and Usluel (2019); Yang and Yang (2019); Aljuhani *et al.* (2020); Brenes-Monge *et al.* (2020); Chen and Hu (2020); Juggernath and Govender (2020); Mlambo, Rambe and Schlebusch (2020); Trujillo-Torres *et al.* (2020); Wu *et al.* (2020); Hossein-Mohand *et al.* (2021); Xu *et al.* (2021); Aydin (2022); Guo, Qiao and Ibrahim (2022); Istenic and Lebenicnik (2022); Lomos, Luyten and Tieck (2023)
F7	bonuses (incentives) for teachers'	Teye and Duah (2022)
F8	cognitive barrier	Ogundile et al. (2019); Buda (2020)
F9	communication barrier	Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017); Li et al. (2019); Brenes-Monge et al. (2020); Bati and Workneh (2021); Xu et al. (2021); Istenic and Lebenicnik (2022); Thannimalai et al. (2022); Zenda and Dlamini (2023)
F10	confidence in using ICT resources such as tablets, interactive whiteboards (IWB)	Yang and Yang (2019); Prodani *et al*. (2020)
F11	creativity	Tomczyk et al. (2017)
F12	cyberbullying	Sittichai and Smith (2020)
F13	ease of use	Hatlevik (2017); Farisi, Ezar Al Rivan and Indra Sensuse (2018); Buabeng-Andoh (2019); Uslu and Usluel (2019); Owen *et al.* (2020); Prodani *et al.* (2020); Wu *et al.* (2020); Alagumalai and Buchdahl (2021); Rudhumbu, Du Plessis and Mudau (2021); Sundqvist, Korhonen and Eklund (2021); Aydin (2022); Guo, Qiao and Ibrahim (2022); Koh *et al.* (2022); Van Greunen and Fosu (2022)
F14	exorbitant (socioeconomic) or high cost of technologies, data, and so forth.	Drossel, Eickelmann and Vennemann (2020); Aydin (2022); Ssenyonga *et al.* (2022)
F15	experience (novice) in ICT	Yang and Yang (2019); Aydin (2022); Ssenyonga *et al.* (2022); Amirova *et al.* (2023)
F16	funding (finance) and/or donors from NPOS, private, government (govt), and public sector, and support	Gerick, Eickelmann and Bos (2017); Farisi, Ezar Al Rivan and Indra Sensuse (2018); Buabeng-Andoh (2019); Chen *et al.* (2019); Ogundile *et al.* (2019); Paunova-Hubenova, Terzieva and Todorova (2019); Uslu and Usluel (2019);

		Yang and Yang (2019); Aljuhani *et al.* (2020); AlSadrani *et al.* (2020); Brenes-Monge *et al.* (2020); Buda (2020); Owen *et al.* (2020); Prodani *et al.* (2020); Seifu (2020); Bati and Workneh (2021); Marcinkovic, Abersek and Pesek (2021); Rudhumbu, Du Plessis and Mudau (2021); Shah *et al.* (2021); Sundqvist, Korhonen and Eklund (2021); Al-Mamary (2022); Mhlana, Chipangura and Twinomurinzi (2022); Sawyerr and Agyei (2022); Ssenyonga *et al.* (2022); Teye and Duah (2022); Wang and Ko (2022); Xiao and Hew (2022)
F17	health challenges	AlSadrani et al. (2020); Buda (2020); Li et al. (2021)
F18	ICT skills (knowledge, competency)	Fan *et al.* (2016); Hatlevik (2017); Tomczyk *et al.* (2017); Buabeng-Andoh (2019); Chen *et al.* (2019); Li *et al.* (2019); Paunova-Hubenova, Terzieva and Todorova (2019); Uslu and Usluel (2019); Yang and Yang (2019); Brenes-Monge *et al.* (2020); Drossel, Eickelmann and Vennemann (2020); König, Jäger-Biela and Glutsch (2020); Mlambo, Rambe and Schlebusch (2020); Owen *et al.* (2020); Prodani *et al.* (2020); Seifu (2020); Ahmed *et al.* (2021); Graca, Quadros-Flores and Ramos (2021); Hossein-Mohand *et al.* (2021); Marcinkovic, Abersek and Pesek (2021); Pozas and Letzel (2021); Sundqvist, Korhonen and Eklund (2021); A'Mar and Eleyan (2022); Mahlo and Waghid (2022); Sulistiyo *et al.* (2022); Thannimalai *et al.* (2022); Van Greunen and Fosu (2022); Lomos, Luyten and Tieck (2023)
F19	lack of ICT infrastructure / poor infrastructure, electricity (power) supply (lack of ICT resources)/ availability	Eickelmann, Gerick and Koop (2017); Hu and Yelland (2017); Lee, Kim and Lee (2017); Ogundile *et al.* (2019); Paunova-Hubenova, Terzieva and Todorova (2019); Yang and Yang (2019); Aljuhani *et al.* (2020); AlSadrani *et al.* (2020); Brenes-Monge *et al.* (2020); Buda (2020); König, Jäger-Biela and Glutsch (2020); Owen *et al.* (2020); Prodani *et al.* (2020); Seifu (2020); Thapa, Griffiths and Kolodziejski (2020); Trujillo-Torres *et al.* (2020); Wu *et al.* (2020); Ahmed *et al.* (2021); Bati and Workneh (2021); Cebrián-cifuentes *et al.* (2021); Graca, Quadros-Flores and Ramos (2021); Tang (2021); Al-Mamary (2022); Canese *et al.* (2022); Gomez-Fernandez and Mediavilla (2022); Guo, Qiao and Ibrahim (2022); Mahlo and Waghid (2022); Mhlana, Chipangura and Twinomurinzi (2022); Sawyerr and Agyei (2022); Ssenyonga *et al.* (2022); Sulistiyo *et al.* (2022); Teye and Duah (2022); Van Greunen and Fosu

		(2022); Gamit (2023); Shala and Grajcevci (2023); Zenda and Dlamini (2023)
F20	leadership (management and strategies)	Eickelmann, Gerick and Koop (2017); Aljuhani et al. (2020); A'Mar and Eleyan (2022); Wang and Ko (2022)
F21	magnitude of classroom	Seifu (2020); Bati and Workneh (2021)
F22	motivation	Prodani *et al.* (2020); Seifu (2020); Gomez-Fernandez and Mediavilla (2022); Guo, Qiao and Ibrahim (2022); Ssenyonga *et al.* (2022); Sulistiyo *et al.* (2022); Teye and Duah (2022); Thannimalai *et al.* (2022); Wang *et al.* (2022)
F23	online assessments and e-books	Paunova-Hubenova, Terzieva and Todorova (2019); Zenda and Dlamini (2023)
F24	over-digitalization of education	Buda (2020)
F25	policies or protocols	Wu et al. (2020); Guo, Qiao and Ibrahim (2022); Mahlo and Waghid (2022); Zenda and Dlamini (2023)
F26	poor attendance of teachers and learners in ICT classrooms' and/or bunk classes	Marcinkovic, Abersek and Pesek (2021)
F27	reading performance	Xiao and Hew (2022)
F28	Restriction access (accessibility)	Brenes-Monge *et al.* (2020); Owen *et al.* (2020); Prodani *et al.* (2020); Bati and Workneh (2021); Marcinkovic, Abersek and Pesek (2021); A'Mar and Eleyan (2022); Al-Mamary (2022); Canese *et al.* (2022); Mhlana, Chipangura and Twinomurinzi (2022); Nouri, Zandi and Etemadizade (2022); Sawyerr and Agyei (2022); Ssenyonga *et al.* (2022); Teye and Duah (2022); Van Greunen and Fosu (2022); Gamit (2023)
F29	shortage of modern software	Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017); Ogundile et al. (2019); Buda (2020); Shala and Grajcevci (2023)
F30	social influence	Garcia, Aunario and Handriyantini (2019); Bauwens *et al.* (2020); Mhlana, Chipangura and Twinomurinzi (2022); Sawyerr and Agyei (2022)
F31	sociodemographic factors(gender, age, race)	Cussó-Calabuig, Farran and Bosch-Capblanch (2017); Zhou *et al.* (2017); Buabeng-Andoh (2019); Trujillo-Torres *et al.* (2020); Wu *et al.* (2020); Kim *et al.* (2021); Li *et al.* (2021); Rudhumbu, Du Plessis and Mudau (2021); Aydin (2022); Becker (2022); Mahlo and Waghid (2022); Gamit (2023)
F32	stereotype	Cussó-Calabuig, Farran and Bosch-Capblanch (2017)

F33	style of teaching	Eickelmann, Gerick and Koop (2017); Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017); Yang and Yang (2019); Sawyerr and Agyei (2022)
F34	supervision of school principals	Wang and Ko (2022)
F.35	time	Buda (2020); Seifu (2020); Marcinkovic, Abersek and Pesek (2021); Al-Mamary (2022)
F36	training	Gil-Flores, Rodriguez-Santero and Torres-Gordillo (2017); Buda (2020); Owen *et al.* (2020); Ahmed *et al.* (2021); Bati and Workneh (2021); Pozas and Letzel (2021); A'Mar and Eleyan (2022); Al-Mamary (2022); Gomez-Fernandez and Mediavilla (2022); Mahlo and Waghid (2022); Teye and Duah (2022); Zenda and Dlamini (2023)
F37	willingness	Chen *et al.* (2019)
F38	work-overload	AlSadrani et al. (2020)

The following diagram demonstrates a visual dataset based on the observation data in Table 3.3. The table included N=38 participants (factors) from various studies from 2017-2023 extracted from Scopus and Web of Science academic databases. The diagram denotes the number of years and several studies published in each year. It also demonstrates the chronological profile of ICT adoption studies with the number of papers (pp) and year of publication.

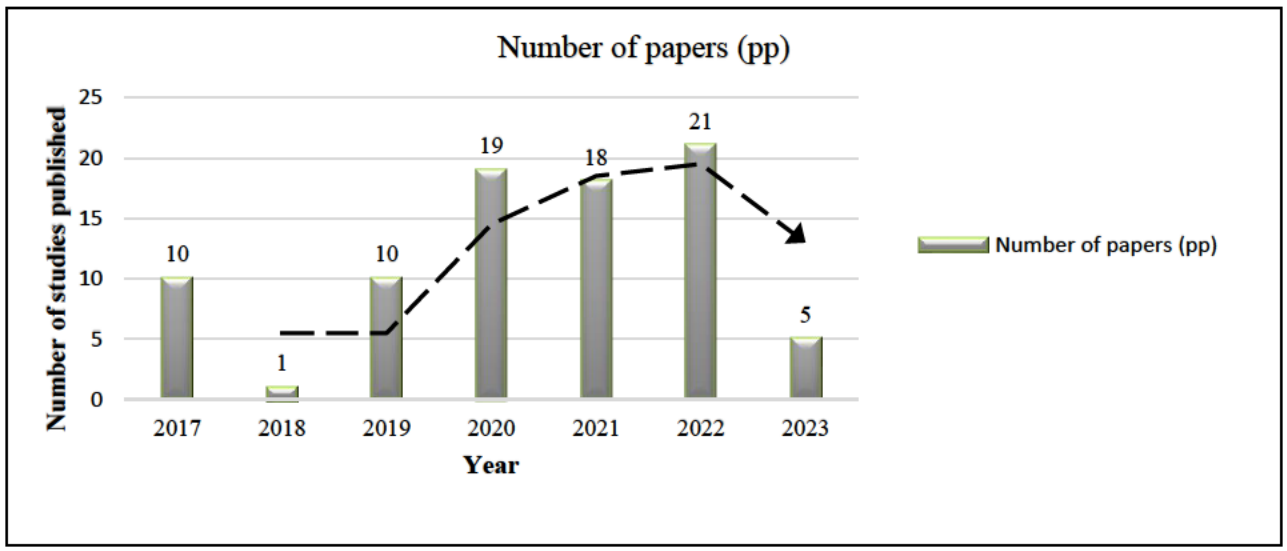

Figure 3.3: Chronological profile of the ICT adoption studies (2017-2023)

Figure 3.3 chronological profile of ICT adoption studies from 2017 to 2023. The profile shows that 2017 has 10 studies published, followed by 2018 with a very low number 1 of studies published, while 2019 displayed 10 studies. In 2020 the number of studies increased to 19. The reason for that, the pandemic prompted studies on how the shift to remote learning affected learners

in developing countries, including the challenges faced in accessing online education and the effectiveness of virtual learning environments. These challenges lured many researchers to investigate the challenges that will affect learners to adopt ICT in the world. As shown in Figure 3.3, 2020 (19) is in the second peak, followed by 2021 (18). The drop-off numbers of studies from 19 to 18 shows the decreasing number of studies. In 2022, the number of studies climbed to 21, which is the highest value of the chronological profile of studies. Despite the increase between 2022, 2020, and 2021, 2023 reveals a lower number of studies, 5 published instead of burgeoned. The lower number in 2023 was caused by this, the data was collected from 2017 to May 2023, 01:35 AM, not December 2023.

These studies reflect the evolving landscape of ICT adoption, highlighting both technological advancements and the challenges associated with integrating new technologies into various sectors such as educational contexts. Despite the landscape of ICT adoption, ICT advancements, and pressing issues associated with ICT in rural secondary schools in the Sub-Saharan Africa (SSA) region, the principal component analysis technique was used to analyse the dataset in Figure 3.4 (see Figure 3.5) principal component analysis.

Figure 3.4 shows the grouping factors by the number of authors generally involving organizing factors. Grouping factors based on the number of authors involved, so, it is significant to categorize them in a way that shows the nature of collaboration. One author can share more than one factor in a plotted diagram.

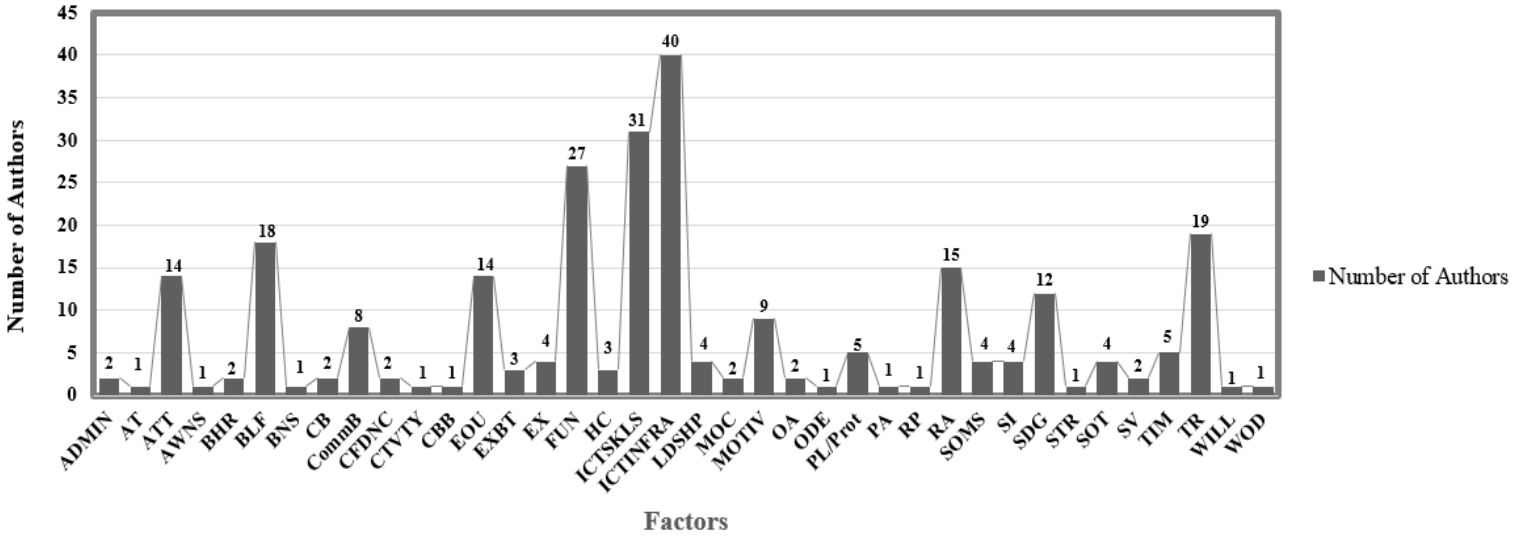

Figure 3.6: Grouping factors by the number of authors

Abbreviations of ICT factors: Administrative (ADMIN), Anxiety (AT), Attitude (ATT), Awareness (AWNS), Behavior (BHR), Beliefs (BLF), Bonuses (BNS), Cognitive barriers (CB), Communication barrier (CommB), Confidence (CFDNC), Creativity (CTVTY), Cyberbullying (CBB), Ease of use (EOU), Exorbitant (EXBT), Experience (EX), Funding (FUN), Health challenges (HC), ICT skills (ICTSKLS), Lack of ICT infrastructure (ICTINFRA), Leadership (LDSHP), Magnitude of classroom (MOC), Motivation (MOTIV), Online assessments (OA), Over-digitalization of education (ODE), Policies or protocols (PL/Prot), Poor attendance (PA), Reading performance (RP), Restriction access (RA), Shortage of modern software (SOMS), Social influence (SI), Sociodemographic factors (SDG), Stereotype (STR), Style of teaching (SOT), Supervision (SV), Time (TIM), Training (TR), Willingness (WILL), and Work-overload (WOD).

Number of author/s identified by author/s are presented on the top of each bar in Figure 3.5. Figure 3.5, shows that ICT infrastructure is the major factor influencing the widespread adoption of ICT, this is referenced by 40 authors. According to Aruleba and Jere (2022); Tsimba, Mugoniwa and Mutembedza (2023); Pradana and Josiah (2024), rural communities face strong challenges of inadequate access to ICT services and infrastructure. This is followed by ICT Skills with 31 authors identified as a persisting challenge in the adoption, acceptance, use, and integration of ICT. Challenges of ICT skills in rural secondary schools in developing countries caused by the shortage of ICT infrastructure (Wang, Tigelaar and Admiraal 2022; Kalimaposo *et al.* 2023; Pradana and Josiah 2024). The funding or support is in line with other factors influencing the widespread adoption of ICT, based on 27 authors. Limited budgets in rural areas affect ICT adoption in secondary schools, financial constraints affect infrastructure development, as well as technology accessibility affects learners in rural schools (Kumari and Srivastava 2023). Furthermore, challenges of funding accompany with inadequate funding, exorbitant ICT resources, and poor implementation of policies by the government (Bolaji and Jimoh 2023).

An insufficiency of ICT training influences the adoption of ICT with 19 authors emphasising identifying this as an influential factor, followed by belief with 18 authors arguing by mentioning belief as a challenging factor in the adoption of ICT. Several authors (15) identified restriction access as the key factor as well. This is in line with 14 authors' identified attitude as one of the factors influencing the widespread adoption of ICT, while other 12 authors identified sociodemographics as one of the factors influencing it. Even though, different authors 9, found that motivation is affecting ICT adoption, as well as communication barriers identified by 8 authors. In addition, time and policies or protocols affect the widespread adoption of ICT in education. This is confirmed by many authors in Figure 3.4. the rest of the factors are identified by authors from four to one. This shows that these factors have a lower number of authors who discussed them in preceding studies.

This type of partitioning helps in realizing the scope of collaboration and the nature of contributions involved in developing various factors in data collection. Based on Figure 3.5, addressing these challenges often requires a multifaceted approach, including increased investment, better policy frameworks, training programs, and community involvement to enhance ICT infrastructure in rural secondary schools. So, if the Department of Basic Education (DBEd)

and policymakers can focus on addressing these challenges, rural secondary school learners in rural communities can improve their academic performance.

3.2.2.1 Data Codification

It is a step that takes raw data and alters it into a format that can be easily analysed, typically by assigning numerical or categorical codes to represent different attributes. In this study, the data used for analysis were obtained from the included studies of PRISMA. This data was then exported into an Excel spreadsheet and converted into a binary format of 0s and 1s, with a value of 1 assigned to authors who agreed with certain factors and 0 to those who did not. Furthermore, codification guidelines allow the manipulation of the dataset included. In particular, the categories were determined by the authors of the extant literature based on authors who agreed and disagreed converted into the binary format of (0s and 1s). As shown in Table 3.4 presents a sample of data codification used in this study. Codification applied in a systematic literature review, for example, Varma, Nehansh and Swathy (2023) applied codification techniques in data preprocessing toolkit.

Table 3.4: Data Codification Of Factors.

Author/s and Year of Publication	Anxiety	Attitude	Awareness	Beliefs	Capacity	Communication
Cussó-Calabuig, Farran and Bosch-Capblanch (2017)	1	0	0	0	0	0
Tomczyk *et al.* (2017)	0	1	0	0	0	0
Paunova-Hubenova, Terzieva and Todorova (2019)	0	1	0	0	0	0
Xu et al. (2021)	0	0	1	1	0	1
Kiru (2018)	0	0	0	0	0	1
Atman Uslu and Usluel (2019)	0	0	0	0	0	0
Yang and Yang (2019)	0	0	0	0	0	0
Jogezai, Baloch and Ismail (2020)	0	0	0	0	1	0
Bati and Workneh (2021)	0	0	0	0	1	1
Brenes-Monge *et al.* (2020)	0	0	0	0	0	1

The data codification is in the preprocessing phase. This study processed the dataset in a format that allows us to convert the dataset into principal component analysis. The dataset was cleaned and processed in a format for principal component analysis, so there is no tokenization and stopping words removed applied in this study. This study used Inclusion and Exclusion Criteria (IEC) (see Table 3.4) to know what type of data needs to be included in the study. The study included those studies that meet the aim, and objectives of the study based on the IEC, then extracted factors from those included studies. Based on those factors, this study applied data codification, where preprocessing is counted. The data was preprocessed, to put that dataset in a format that allows us to conduct PCA.

3.3.3 Principal Component Analysis

Principal component analysis (PCA) is a multivariate statistical method used to summarize big data into new variable principal components (PC), which are the smaller variables that can be used to develop without missing significant data (Hanci and Cebeci 2019). The principal component analysis is a widely used statistical method for reducing the dimensionality of multivariate datasets across various scientific disciplines (Camargo 2022).

The goal of PCA is to maximize the variance in the data, with each subsequent component accounting for less variance than the previous one. In PCA, the first few components retain the most variation in the original variable, and there are similarities between visualization, as shown in PC, eigenvalue, percentage of variance, and cumulative variance. Principal Component Analysis (factor analysis) is a multivariate statistical procedure commonly used in information systems, psychology, commerce, and education. It is the preferred method for interpreting self-reported survey data. It reduces a large number of variables (factors) into a smaller set of 'artificial' variables by creating new variables called principal components, which report the most significant contribution to the variability observed in the original variables. Moreover, it establishes a relationship between measured factors and latent constructs, thus enabling the development and refinement of theories (Taherdoost, Sahibuddin and Jalaliyoon 2022).

The PCA has many advantages, such as speeding up the learning algorithm, increasing efficiency due to lower dimensions, reducing the necessary storage capacity, visualizing data, extracting identical variables, reducing noise, and compressing the dataset. In addition, we should keep some crucial characteristics of PCA in mind. For instance, the number of principal components is always less than or equal to the number of attributes. These components are orthogonal to each other and decrease in number as we move along. They are ordered in terms of variance, with the highest at the top. Furthermore, PCA forms a new basis for representing the data coordinates. Constructed variables in PCA are typically insignificant and uncorrelated. The first and second PCs usually carry the most information, followed by the third, and so on. Negative values are typically considered the least important variables in PCA and are generally found at the bottom of the principal components.

3.3.3.1 How does principal component analysis work?

The PCA performs the following work to evaluate the principal component of a dataset.

Standardization (SD): this aims to normalize the range of the variables so that each one lies between similar boundaries. It comprehends the extraction of the mean from the variable values, scaling the data concerning the SD.

$$X= \frac{variable\ value - means}{SD} \qquad \text{Eq. (3.2)}$$

The covariance matrix expresses relationships within any two or more variables in the multidimensional dataset. The covariance matrix has entries for the variance and covariance of the variable values. The variance is represented as '*Var'* and covariance as '*Cov.'*

$$\begin{pmatrix} Cov(x) \\ Var(x,y) \end{pmatrix} \quad \text{Eq. (3.3)}$$

It informs us how the two or more variables are linked. In this, positive covariance shows that the values of one variable are directly proportional to each other (variable). In contrast, negative covariance shows that the values of one variable are inversely proportional to each other. Eigenvalues are the scalars, the set of mathematical values that are omitted from the covariance table. They are responsible for creating a new set of variables from the old set of variables, which further leads to constructing a new set of variables called PC.

A feature vector is a matrix that has eigenvectors of the components that have been decided to be stored as columns. In this study, the researcher has decided to discard insignificant PC.

$$X = \begin{matrix} PC1 \\ PC2 \\ PC3 \\ . \\ . \\ PC38 \end{matrix} \quad \text{Eq. (3.4)}$$

This study aims to report various determinant factors that affect the widespread adoption of ICT and the disparity between rural secondary schools in developing countries. Principal component analysis was employed to identify the weight of each variable in the dataset. The dataset was converted to standardized units before the analysis. The number of PCA was discovered by using minimum eigenvalues. So, all the statistics in this section were obtained using R-Studio software version 4.2.3.

3.3.4 Comparative analysis

This section focuses on Qualitative Comparative Analysis (QCA) by comparing an existing framework with a new one. According to Tripathy *et al.* (2024), comparative analysis aids in examining various approaches based on multiple characteristics. This study compares the existing frameworks such as the Technology Acceptance Model (TAM), Task Technology Fit (TTF), and Unified Theory of Acceptance and Use of Technology (UTAUT) models with the Extended Unified Theory of Acceptance and Use of Technology (XUTAUT) framework.

To adequately compare the proposed framework with well-known frameworks, 14 constructs were used to validate the contributions of each framework. These constructs include Perceived usefulness, Perceived ease of use, Behavioral intention, Social influence, Effort expectancy,

Performance expectancy, Facilitating condition, Task characteristics, Technology characteristics, Health challenges, Cognitive barriers, Time constraints, Over-digitalization of Education, and Funding. These constructs provide a comprehensive basis for evaluating and contrasting the effectiveness and applicability of the proposed framework against well-known frameworks in the field.

3.3 Chapter Summary

This chapter has shown the different steps of methodology needed to understand the study's aim and objectives. The study presented the methodological framework with a sufficient description. A study methodological framework attributes for example data collection, data pre-processing, codification, principal component analysis, and comparative analysis discussed in this chapter. Further, the principal component analysis method was employed, and its performance. The next chapter will unpack the evaluation experiments, the final results, the potential results associated with the reviewed extant literature, and the proposed aim, objectives, and research questions using R-Studio 4.2.3 software.

CHAPTER 4 : PRESENTATION OF RESULTS AND DISCUSSION

4.1 Introduction

This chapter implements the principal component analysis introduced in chapter three. The primary objective of this chapter is to unpack the research methodology applied in this study. This chapter specifically aligns with the study research question and describes the considerations guiding the methodology of this study. It also summarises the research techniques used in the change study framework to align with the study's overarching purpose.

This chapter begins with *Section 4.2* results analysis of 38 factors that influence the ubiquitous adoption of ICT in rural schools. The rest of this chapter (chapter four) is planned as follows: *Section 4.3* is the principal components of the factors, *Section*, *Section 4.4* is the communality, *Section 4.5* is the principal component analysis plot of variables with contribution, *Section 4.6* is the study framework, *Section 4.7* discusses the advantages of why this study developed extended framework. Furthermore, *Section 4.8* describes the intrinsic and extrinsic variables, *Section 4.9* discusses the validity of this study, *Section 4.10* distinguishes existing theory and *Section 4.11* presents the chapter summary for chapter four. The following section discusses the results analysis of this study based on the aforementioned sections.

4.2 Results analysis

The scree plot presented in Figure 4.1 explains the proportion of the cumulative variance in the original dataset of 38 variables that are analyzed by each component. Usually, it helps to observe how many elements are imperative to analyze the data. The x-axis of the scree plot presents the

principal component (dimensions), while the y-axis presents the eigenvalue associated with each Principal Component (PC).

In R-Studio, this study uses factoextra(), library() and fviz_screeplot (arg1, arg2, arg3…) function, for example fviz_screeplot (fpca, ncp=38, geom="line", xlab="Dimesnsions", main = "Scree Plot", choice='eigenvalue', linecolor="brown", addlabels=T, hjust = -0.5, ldw=4) to visualize data. The first three dimensions in the plot explain the highest percentage of the variance, with a reduced variance explained by the subsequent dimensions. The last principal component will be having the least amount of information context.

In the scree plot, the “elbow” effect was employed. The “elbow” effect of the scree plot confirms that these dimensions are extractable from Dim 1 to Dim 3 because the beginning of the “elbow” starts at Dim 3. Although the bending occurs at Dimension 3 to Dimension 9, it begins at Dim 3 to curve or form the “elbow” shape. Based on the “elbow” curve, three dimensions are extracted based on the weighting of the eigenvalue. After the bend in Dimension 18, the curve starts to flatten out, and the following dimensions become trivial or insignificant. Potapov, Longo and Lubk (2018) summarized that the number of cut-off values might display the number of significant principal components in PCA analysis helping in the extraction of significant data. Therefore, a PC with less than one eigenvalue can be considered trivial. The separation spot occurs at Dim 3, where the slope seems to decrease after Dimension 3. In this scree plot, the study will use the selected number of components based on Dim 1 and Dim 2.

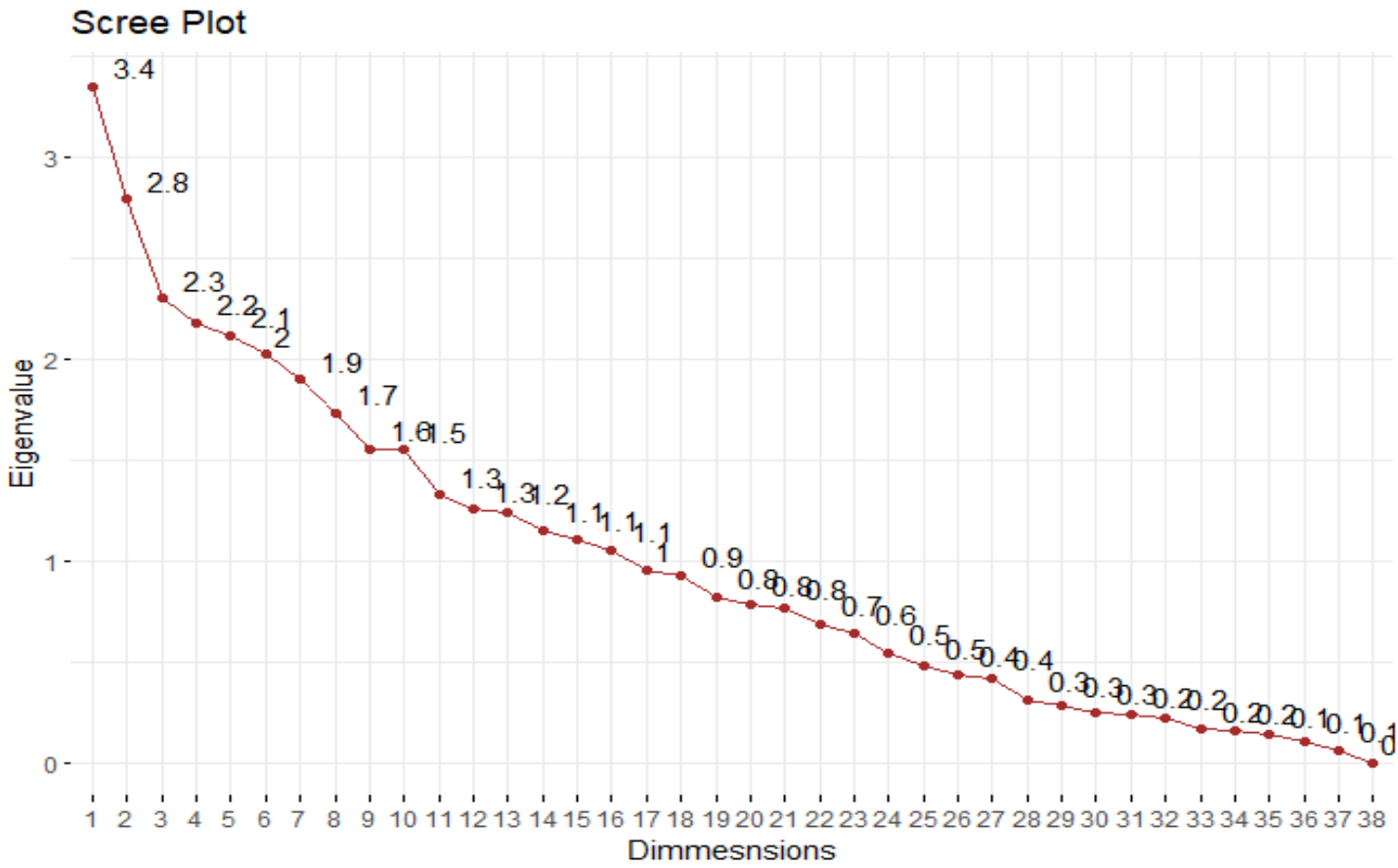

Figure 4.1: Scree plot for PC1-PC38

The first three components are the most significant in explaining data variability. The *fpca$eig* function in R-Studio (R) was used to generate the three-cluster principal component, eigenvalue, Standard deviation (Sdv), % of the variance, and cumulative percentage of variance. This will help in analyzing the factors influencing the widespread adoption of ICT among rural secondary learners in developing countries. However, the number of principal components is equal to the number of dimensions of the scree plot of 38 variables. Each Principal Components (PC) has an eigenvalue. So, the eigenvalue is the square of Standard deviation (Sdv) and variance is a square of Sdv; for example, how eigenvalue is used to calculate the dimension?

$$\text{Sdv} = \sqrt{eigenvalue} = \sqrt{variance} \quad , \qquad \text{Eq. (4.1)}$$

$$\text{So, eigenvalue} = (Sdv)^2, \qquad \text{Eq. (4.2)}$$

The cumulative proportion is the total proportion of the principal component. The cumulative proportion can not be null. So, to find out the total proportion of each PC, apply the calculations. For instance, to find the cumulative proportion of PC2, add the first two proportions of variance for PC1 and PC2 to get the total proportion. The proportion of variance is sorted from the highest

to the lowest. As seen on the scree plot, much of the information can be explained in dimensions one and two. The first and second dimensions retain more information compared to dimension three, and the last dimension, 35, retains the most negligible information content of the original variable.

4.3 Principal components of the factors Table 4.1 presents the principal components, eigenvalue, percentage of variance, and cumulative component variance for the 38 principal components of R-Studio. The percentages on R-Studio software version 402.3 are eigenvalue (3,34 to 0,06), percentage of variance (8,79 to 0,16), and percentage of cumulative variance (8,79 to 100). Likewise, all other researchers used PCA to reduce dimensionality in education, agriculture, health, climate, etc. Pursan, Adeliyi and Seena (2023) used PCA to analyze success factors in the information technology technical support department at the Durban University of Technology (DUT), and Hanci and Cebeci (2019) applied PCA in the analysis of pisum genotypes. Furthermore, Epizitone and Olugbara (2020) applied PCA in the study of critical success factors for enterprise resource planning systems.

Table 4.1 Compares the outputs of principal components of the factors affecting the widespread adoption of ICT among rural secondary learners in developing countries with R-Studio software.

Table 4.1: Dimension 2 Quantitative Variables.

Principal components on R-Studio initial eigenvalue			
principal component	eigenvalue	variance %	cumulative component variance (%)
PC1	3,34	8,79	8,79
PC2	2,78	7,30	16,10
PC3	2,29	6,02	22,12
PC4	2,11	5,55	27,67
PC5	2,04	5,37	33,04
PC6	1,95	5,13	38,17
PC7	1,79	4,71	42,88
PC8	1,64	4,31	47,19
PC9	1,56	4,12	51,31
PC10	1,53	4,02	55,33
PC11	1,32	3,48	58,81
PC12	1,26	3,31	62,12
PC13	1,18	3,11	65,22
PC14	1,13	2,96	68,19
PC15	1,11	2,91	71,10
PC16	1,05	2,77	73,87
PC17	1,03	2,71	76,58
PC18	0,94	2,47	79,05
PC19	0,93	2,44	81,49

PC20	0,81	2,13	83,62
PC21	0,78	2,05	85,67
PC22	0,72	1,89	87,56
PC23	0,67	1,77	89,33
PC24	0,64	1,68	91,00
PC25	0,51	1,35	92,36
PC26	0,48	1,26	93,62
PC27	0,43	1,12	94,74
PC28	0,36	0,94	95,68
PC29	0,29	0,77	96,44
PC30	0,25	0,66	97,10
PC31	0,24	0,62	97,73
PC32	0,23	0,61	98,34
PC33	0,17	0,45	98,79
PC34	0,16	0,41	99,20
PC35	0,14	0,36	99,56
PC36	0,11	0,28	99,84
PC37	0,06	0,16	100,00
PC38	0,00	0,00	100,00

In Table 4.1, PC17 represents 1.03 eigenvalue, 2.71 percentage of variance, and 77 cumulative percentage of variance. This shows that all variables below PC17 are insignificant because the heuristic procedural analysis states that eigenvalues greater than one are significant; if they are less than one, they are trivial or insignificant. So,the final cumulative percentage of variance is 100%. As a result, all 38 variables in Table 4.1 are analyzed in R software with PCA methodology. PC38 does not correlate standard deviation and the percentage of variance; the relationship is 0.00, which means there is no correlation.

4.4 Communality

The commonalities are clustered into three columns: factors (F), initial, and extraction. Table 4.2 presents the communality variables from the principal component of variables communality. “Communality” is a statistical measure that indicates the proportion of variability in a variable that can be explained by common factors (Hair *et al.* 2006). The communality shown in Table 4.2 describes each factor loading that can be applied for extraction, which is displayed between the range of 0.634353 minimum to 0.9768229 maximum for the extracted principal component. It further strengthens to show the result analysis.

Each row in the table represents an observed variable, and each column represents a factor. The values in the table indicate the extent to which each factor contributes to the variance of each variable. The significance of factors in communality is the assessment of the significance of each variable, dimensionality reduction, interpretation of factors, and design evaluation. In summary,

the significance of factors in the communality table provides a significant understanding between identified variables and supporting factors.

In PCA, communality represents the proportion of variance in an observed variable that is accounted for by the common factors. Principal component analysis, on the other hand, focuses on explaining the maximum variance in the dataset without making assumptions about unused factors. The communality table has a 0.9768229 maximum for the component extracted. Extraction communality is the proportion of variance explained by each PC that can be considered as the "extraction communality".

The commonality value ranges from 0 to 1. A value of 1 indicates that the variable's variance is perfectly correlated with other variables due to shared factors. F1 is 0.938 and has a value of 0.94%, indicating that it shares 94% of its characteristics with other variables due to common factors. The remaining 6% is unique to F1 and is influenced by other factors. The extraction value for the principal component (PC) expounded at 0.634, while the highest, 0.976, extracted values are for F2 (anxiety) and F32 (stereotype). So, these values from 0.634 to 0.976 were integrated to explain the highest eigenvalue, as shown in the first and second PC. The first, second, and third PC retains significant information as depicted in the first PC.

One variance can explain 100% as the output of 1 communality, while the variance with insuffience details is represented by 0 communality. The commonality is usually given as:

$$\hat{h}_i^2 = \sum_{j=1}^{m} \hat{l}_{ij}^2 \qquad \text{Eq. (4.3)}$$

Where, h_i is the communality of the i^{th},

l_{ij} is the loadings between j^{th} common variable, and i^{th} variable.

Table 4.2: Communalities Of Factors Affecting The Widespread Adoption Of ICT.

Factors (F)	Initial	Extraction						
F1→ ADMIN	1.00	0.9387375	F2→ AT	1.00	0.9768229	F3→ ATT	1.00	0.785211
F4→ AWNS	1.00	0.8038597	F5→ BHR	1.00	0.9187403	F6→ BLF	1.00	0.634353
F7→ BNS	1.00	0.7905557	F8→ CB	1.00	0.8214942	F9→ CommB	1.00	0.816083
F10→ CFDNC	1.00	0.8247582	F11→ CTVTY	1.00	0.8754622	F12→ CBB	1.00	0.961072
F13→ EOU	1.00	0.7762876	F14→ EXBT	1.00	0.8830845	F15→ EX	1.00	0.896644
F16→ FUN	1.00	0.8175012	F17→ HC	1.00	0.7994966	F18→ ICTSKLS	1.00	0.688250
F19→ ICTINFRA	1.00	0.7670578	F20→ LDSHP	1.00	0.8961065	F21→ MOC	1.00	0.895027
F22→ MOTIV	1.00	0.7622150	F23→ OA	1.00	0.8970623	F24→ ODE	1.00	0.803467

F25→ PL/Prot	1.00	0.8667610	F26→ PA	1.00	0.8252447	F27→ RP	1.00	0.940902
F28→ RA	1.00	0.7545657	F29→ SOMS	1.00	0.8064200	F30→ SI	1.00	0.746425
F31→ SDG	1.00	0.7139604	F32→ STR	1.00	0.9768229	F33→ SOT	1.00	0.864830
F34→ SV	1.00	0.832152	F35→ TIM	1.00	0.8598576	F36→ TR	1.00	0.763957
F37→ WILL	1.00	0.9031011	F38→ WOD	1.00	0.8888903			
Extraction method: principal component analysis (PCA)								
Abbreviations of Communalities: Administrative (ADMIN), Anxiety (AT), Attitude (ATT), Awareness (AWNS), Behavior (BHR), Beliefs (BLF), Bonuses (BNS), Cognitive barrier (CB), Communication barrier (CommB), Confidence (CFDNC), Creativity (CTVTY), Cyberbullying (CBB), Ease of use (EOU), Exorbitant (EXBT), Experience (EX), Funding (FUN), Health challenges (HC), ICT skills (ICTSKLS), Lack of ICT infrastructure (ICTINFRA), Leadership (LDSHP), Magnitude of classroom (MOC), Motivation (MOTIV), Online assessments (OA), Over-digitalization of education (ODE), Policies or protocols (PL/Prot), Poor attendance (PA), Reading performance (RP), Restriction access (RA), Shortage of modern software (SOMS), Social influence (SI), Sociodemographic factors (SDG), Stereotype (STR), Style of teaching (SOT), Supervision (SV), Time (TIM), Training (TR), Willingness (WILL), and Work-overload (WOD).								

4.5 The principal component analysis graph

The plot depicting principal component analysis contributions is demonstrated in Figure 4.2. This plot shows the reduction of complexity and highlights the directions of the colossal variance in the data; it also indicates that if two or more variables point in the same direction, it means that they are strongly correlated, but if they form 90^0 angle shows no correlation, and if they are not facing in the same direction (opposite), it means that they are not strongly correlated (negative correlation). In Figure 4.2, variables such as over-digitalization of education, cognitive barriers, and health challenges are strongly correlated at 135^0 angle (second quadrant) because they are pointing in the same direction. Furthermore, funding and time are correlated, pointing at the first quadrant, while the variables such as ease of use, experience, style of teaching, and creativity are not correlated (negatively correlated). The reason for that is they are pointing in the opposite direction, and variables belief and anxiety are uncorrelated because they form 90^0 angle. The highest contribution of these variables is 7.5% (solid red), 5% followed, and 2.5% was the least contribution, with zero to 2.5% describing the negative correlation.

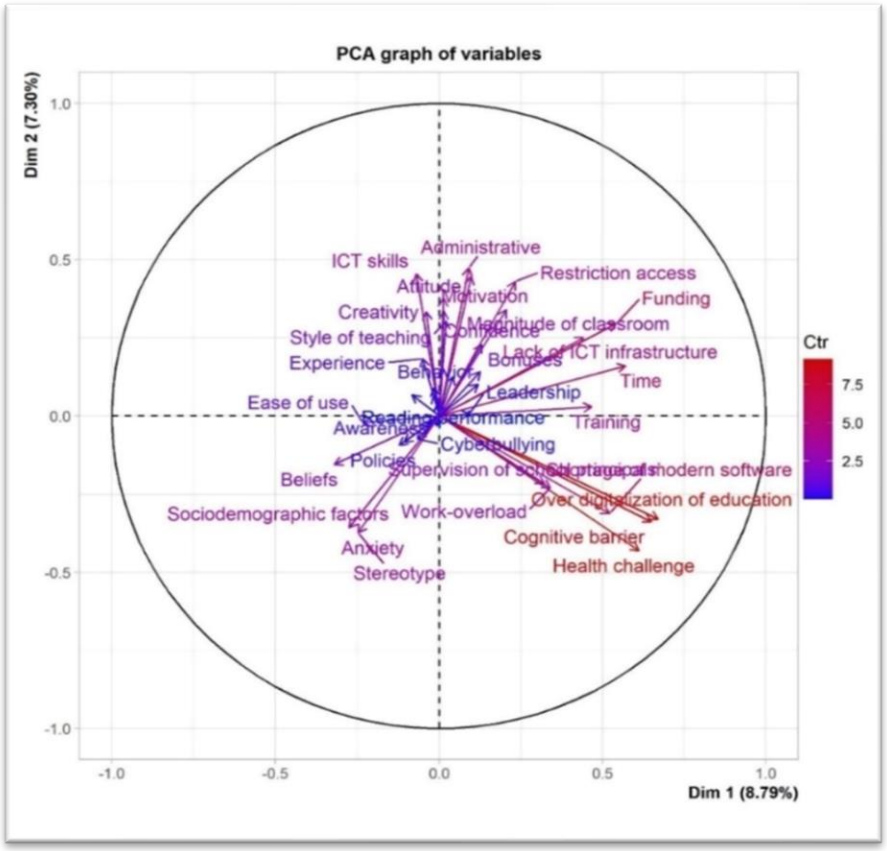

Figure 4.2: PCA graph contribution of each variable

The over-digitalization of education, cognitive barriers, and health challenges will form one group, while funding and time will construct another group. The dataset of this study can be explained by the dataset of five variables in Dimension (Dim 1). The principal component analysis graph results from 38 factors were analyzed in this study with the R-Studio (R) tool. The analysis shows that all the participant factors on the right-hand side significantly contribute to this study. However, Dim 1(8.79%) has the greatest percentage. By contrast, Dimension (Dim 2) (7.30%) has the lowest percentage. The PCA graph is divided into four clusters, and the variables with the highest effect on ICT adoption are represented in Dim 1 (8.79%) with red colours in the first and second clusters. Yet, the second cluster has the greatest dominating factors, for example, over-digitalization of education, cognitive barriers, and health challenges; the first cluster is represented by time and funding.

The results in Dim 1 accommodate contributing factors in the educational domain. The first five variables represent variables, such as over-digitalization of education, cognitive barriers, health challenges, time, and funding, which have the highest effectiveness in rural secondary education. Moreover, contributing factors reveal 7.5%, a mean of 5.0%, and a least 2.5% contribution.

Dim 2 has a minimal contribution to the adoption of ICT among learners in rural secondary schools (RSSs) in developing countries. As a result, this study has decided to pursue factors in Dim 1. This study postulates that other researchers can use factors in Dim 2 to probe their contributions in the educational domain, specifically in developing countries, to combat the lowest adoption of ICT. This could sustain the Department of Basic Education, government branches, and policymakers in dealing with determinant factors in Dim 2 and not abandoning them. The reason for that is this study has decided to use the top five impactful factors in Dim 1 with 7.5% contribution, which is the greatest contribution.

Based on the contribution factors resulted in the analysis of this study, the researcher has decided to utilise them in a proposed framework with prominent constructs of the UTAUT model, for example, social influence, effort expectancy, performance expectancy, facilitating condition, over-digitalization, cognitive barrier, health challenges, time, and funding in an Extended Unified Theory Acceptance and Use of Technology model. Table 4.4, with 16 quantitative variables and Table 4.5, with 21 quantitative variables, discuss correlation and P-value.

In Table 4.4, Dimension 1 has 16 quantitative variables that maintain significant variables for this study, such as over-digitalization of education (ODE), cognitive barriers (CB), health challenges (HC), time (TIM), and funding (FUN). These top five variables are the findings of the principal component analysis graph divided into two dimensions, Dim 1 and Dim 2.

The p-value (probability value) “helps determine if the null hypothesis should be rejected. Careful interpretation based on study design, sample size, and comparability” (Hirschauer, Grüner and Mußhoff 2022). In addition, a lower p-value implies stronger verification against the null hypothesis (Martin 2017; Feng, Li and Sadeghpour 2020; Hirschauer, Grüner and Mußhoff 2022). Dim 2 does not have this study's time and funding, or null values. The null values might be true.

When the p-value < 0.05, then the correlation is significant; if not, it is insignificant. As shown in Dim 1, the top five variables have a p-value > 0.05. Therefore, these variables are significant in this study because of correlation and p-value > 0.05. In Dim 1, over digitalization of education (p-value > -3, 290), cognitive barriers (p-value > -4,310), and health challenges (p-value > -4,310). Therefore, Dim 1 retains the highest significance variables at the top. By contrast, Dim 2 has trivial variables compared to Dim 1. All variables in Dim 2 are lower than variables in Dim 2 except ICT Skills (8.445) and sociodemographic factors (6.427). As a result of that, Dim 1 is better than Dim 2. Based on that, this study could use the top five variables in Dim 1 with the highest percentages compared to Dim 1 with the lowest percentage. In summary, a small p-value does not imply that the effect size between Dim 1 and Dim 2 is significant.

According to Dim 1, it has a better correlation and p-value compared to Dim 2 correlation. All variables in Dim 2 these variables (over digitalization of education, cognitive barriers, and health challenges) are negative, while Dim 1 correlation is positively correlated. This study could adopt variables with positive correlation and p-value > 0.05.

Table 4.3: Comparison of Dim 1 And Dim 2.

Dimension 1-Dim 1			Dimension 2-Dim 2		
Variables	**Correlation-Corr**	**p-value**	**Variables**	**Correlation-Corr**	**p-value**
VAR1-ODE	*6.702E-01*	*9.223E-13*	VAR1-ODE	-3.290E-01	1.750E-03
VAR2-CB	*6.494E-01*	*7.680E-12*	VAR2-CB	-3.385E-01	1.255E-03
VAR3-HC	*6.118E-01*	*2.420E-10*	VAR3-HC	-4.310E-01	2.768E-05
VAR4-TIM	*5.707E-01*	*6.418E-09*	-	-	-
VAR5-FUN	*5.411E-01*	*5.232E-08*	-	-	-

Referring to Table 4.4, the p-value suggests that three factors in Dim 2 are insufficient. The null values are enough, and three factors are insufficient. In Dim 2, the p-value (1.750, 1.255, and 2.768) is less than 0.05 per cent. So, when the p-value is less than the alpha, then the study could reject the null value, p-value = 1.750 < 0.05, 1.255E < 0.05, and 2.768 < 0.05. Therefore, three variables are not appropriate for the data perfectly. The lower p-value suggests a stronger verification against the null value (Martin 2017; Feng, Li and Sadeghpour 2020; Hirschauer, Grüner and Mußhoff 2022). Furthermore, due to the null value, this study could adopt variables in Dim 1 to develop the study framework with supplementary constructs (over-digitalization of education, cognitive barriers, health challenges, time, and funding) strongly correlated with the p-value in Dim 1 quantitative variables. The following table shows the list of variables in Dim 1.

Table 4.4: Dimension 1 Quantitative Variables.

#	**Variables**	**Correlation**	**P-value**
1	*Over-digitalization of education*	*6.702E-01*	*9.223E-13*
2	*Cognitive barriers*	*6.494E-01*	*7.680E-12*
3	*Health challenges*	*6.118E-01*	*2.420E-10*
4	*Time*	*5.707E-01*	*6.418E-09*
5	*Funding*	*5.411E-01*	*5.232E-08*
6	Shortage of modern software	5.214E-01	1.907E-07
7	Training	4.668E-01	4.547E-06
8	Lack of ICT infrastructure	4.418E-01	1.638E-05
9	Work-overload	3.392E-01	1.224E-03
10	Supervision of school principals'	3.213E-01	2.269E-03
11	Restriction Access	2.325E-01	2.926E-02
12	Ease of use	-2.337E-01	2.839E-02
13	Stereotype	-2.477E-01	1.998E-02
14	Anxiety	-2.477E-01	1.998E-02
15	Sociodemographic factors	-2.759E-01	9.277E-03
16	Beliefs	-3.204E-01	2.339E-03

The top five factors affecting the widespread adoption of ICT are extracted from quantitative variables. It can be observed that all 38 variables are reduced to five predominant factors with P-values of 9.223E-13, 7.680E-12, 2.420E-10, 6.418E-09, and 5.232E-08. Also, there is a correlation of 6.702E-01, 6.494E-01, 6.118E-01, 5.707E-01, and 5.411E-01.

Dim 1 included 16 quantitative variables, while dimension 2 included 21 quantitative variables, as presented in Table 4.5 and Table 4.6. A documented detailed correlation analysis in Dim 1 shows that variables like over-digitalization of education show a strong positive correlation with the dimension supported by a correlation coefficient of 6.70. The highest values show a strong correlation between the over-digitalization variable and its coordinated number, suggesting that individuals with high scores on Dim 1 are significantly associated with over-digitalization in education. The significance of this correlation is confirmed by a p-value greater than the 0.05% threshold, indicating that only associations significantly different from zero are considered valid; the rest are discarded.

Transitioning to Dim 2, the correlation analysis is similarly conducted for its 21 quantitative variables. The 'administrative' variable shows a positive correlation with a coefficient of 4.74, suggesting a weaker but significant link with its corresponding dimension number, as individuals with lower scores on Dim 1 are associated with a lesser emphasis on administrative aspects. This relationship differs significantly from zero, supported by a p-value less than 0.05%.

All variables in Dim 2 are sorted from the most positively to the most negatively correlated. Notably, a correlation coefficient in Dim 1 of over-digitalization of education (+6.702E-01) represents a perfect positive linear relationship, while a coefficient of ease of use (-2.337E-01) denotes a perfect negative linear relationship. A coefficient of zero would indicate no linear relationship at all.

Dim 2 quantitative has a low correlation and P-value. By contrast, Dim 1 comprises 16 quantitative variables. The first top five principal factors shown in Dim 1 explain a 30,432% correlation and 30.973% P-value, and Dim 2 contains a 21,817% correlation and 18,752% P-value. Based on these results, Dim 1 has higher contributions than Dim 2. This study has decided to use Dim 1 quantitative variables. Other researchers should use Dim 2 quantitative variables. This could remedy the lack of adoption of ICT in developing countries, specifically in rural secondary schools.

Besides the refurbishment, learners were struggling during the Coronavirus Disease (COVID-19) pandemic in India; this is confirmed by (Debbarma and Durai 2021). Reaching learners to participate in a conducted survey was sophisticated since there was poor internet connectivity in the northern regions of India. So, it is imperative to discuss the lack of ICT infrastructure in Dim 2 and other critical factors.

Table 4.5: Dimension 2 Quantitative Variables.

#	Variables	Correlation	P-value
1	Administrative	4.739E-01	3.112E-06
2	ICT skills	4.550E-01	8.445E-06
3	Motivation	4.461E-01	1.323E-05
4	Restriction Access	4.301E-01	2.881E-05
5	Attitude	3.766E-01	2.991E-04
6	Magnitude of classroom	3.399E-01	1.195E-03
7	Confidence	3.353E-01	1.407E-03
8	Creativity	3.333E-01	1.509E-03
9	Style of teaching	3.046E-01	3.911E-03
10	Funding	2.952E-01	5.239E-03
11	Lack of ICT infrastructure	2.510E-01	1.836E-02
12	Bonuses	2.287E-01	3.211E-02
13	Supervision of school principals'	-2.162E-01	4.309E-02
14	Work-overload	-2.302E-01	3.096E-02
15	Shortage of modern software	-3.115E-01	3.138E-03
16	Over-digitalization of education	-3.290E-01	1.750E-03
17	Cognitive barrier	-3.385E-01	1.255E-03
18	Sociodemographic factors	-3.569E-01	6.427E-04
19	Stereotype	-3.732E-01	3.414E-04
20	Anxiety	-3.732E-01	3.414E-04
21	Health challenge	-4.310E-01	2.768E-05

4.6 The study framework-wide adoption of the ICT Framework

This section provides a general overview of what a study framework typically entails. Specific frameworks may vary depending on the study's discipline, research methodology, and objectives. The study framework for the applied methodology most applicable to the study framework, as described in the study framework below, extends the existing UTAUT model to the extended UTAUT framework. So, the key factors such as social influence, effort expectancy, performance expectancy, and facilitating condition form the study used a model known as a unified theory of acceptance and use of technology with construct variables divided into two groups (intrinsic and extrinsic) variables.

The original UTAUT extended to the XUTAUT framework based on the benefits expounded in the following section and on the extant literature, for example, Ab Jalil, Rajakumar and Zaremohzzabieh (2022); Syam and Kusuma (2023); Tibakanya (2023) applied the UTAUT model

to identify and distinguish factors affecting educational settings. Furthermore, Agyei and Razi (2022); Chand *et al.* (2022); Li, Sun and Oubibi (2022) applied the "extended UTAUT model" in a conducted study. So, the extension of the original UTAUT model to the XUTAUT framework entails new deterrent factors affecting the ubiquitous adoption of ICT among rural secondary schools, which could help policymakers improve the adoption of information and communication technology in developing countries.

Figure 4.3 illustrates the study framework with supplementary variables on the top and bottom. The top variables are internal variables, including health challenges, cognitive barriers, and time while the bottom variables are represented by external variables over-digitalization of education and funding resulting from the R-Studio software version 4.2.3.

4.7.1 Benefits of the Unified Theory of Acceptance and Use of Technology (UTAUT)

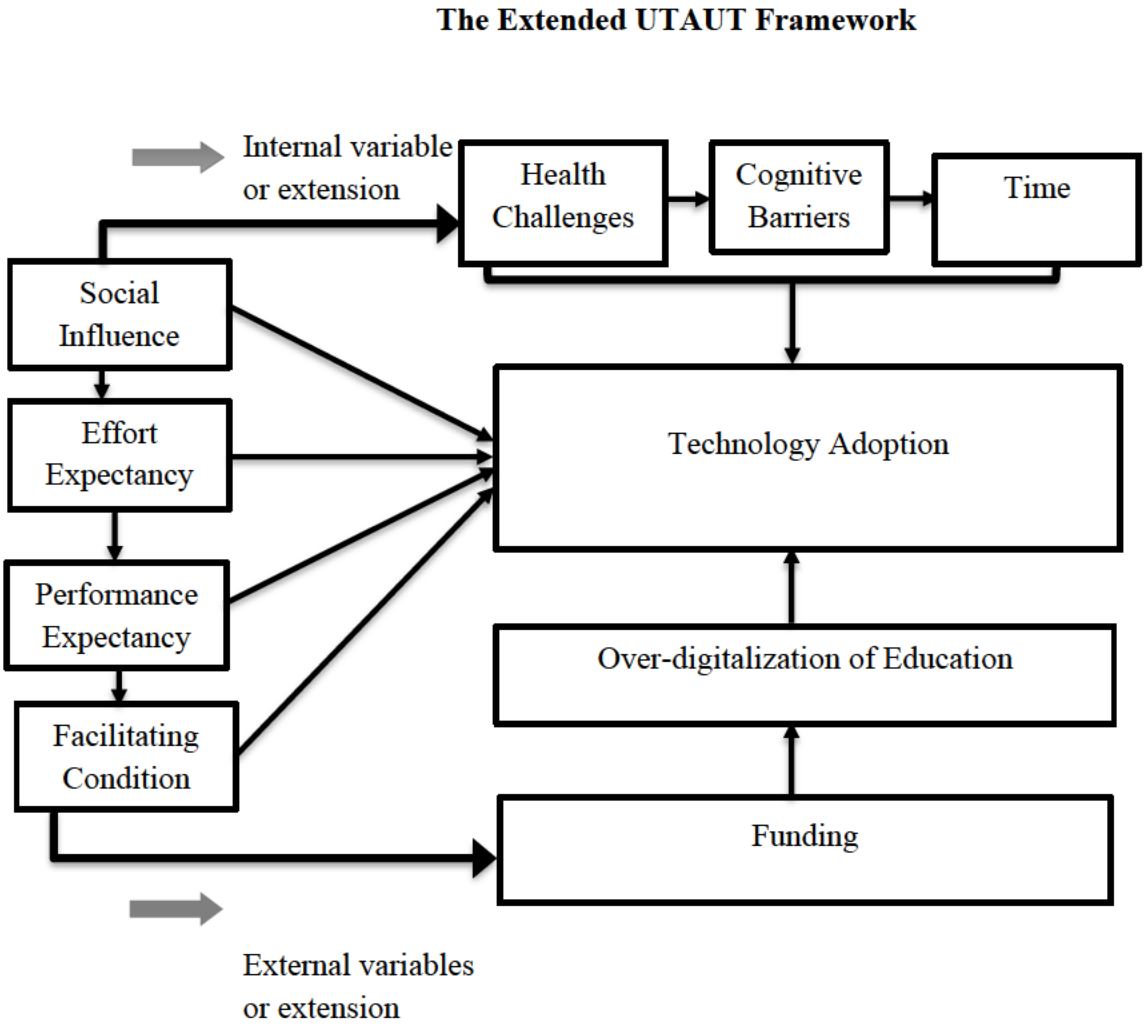

Figure 4.3: Study framework (based on the UTAUT)

4.7 The XUTAUT framework

This study applies the UTAUT model; it is noticed that previous studies constructed upon it never apply it directly, instead changing the context. Therefore, this study will reinforce five additional variables from PCA results, for example, over-digitalization of education, cognitive barriers, health challenges, time, and funding, to the UTAUT model to apply in adopting ICT in developing countries. These top five factors have been identified in PCA to evolve a new study framework; hence, please (see Figure 4.3) study framework (based on UTAUT). The extrinsic and intrinsic variables were supplementary to the original UTAUT to meet the aim of this study.

4.7.1 Social Influence (SI)

Venkatesh *et al.* (2003) described SI as "the degree to which an individual perceives that important others believe he or she should use the new system." A previous study reported the impact of peers, friends, and family on SI (Shen *et al.* 2019). In addition, SI has indicated a positive influence on individual behavioural intention (Teo and Noyes 2014). Venkatesh (2000) reported that women are the victims and, therefore, are likely to be affected by SI when they use technology. The findings of Rogers (1995) suggest that social influence is the major determinant of behavioural intention. Even so, this study posits that learners would increase their ambition to adopt ICT in learning when they are taught at school, and learners are more likely to use technology based on advantages reported with technology.

4.7.2 Effort Expectancy (EE)

Venkatesh *et al.* (2003) explain EE as the simplicity level of using technology by the user. Davis, Bagozzi and Warshaw (1989) suggest that perceived use and perceived ease of use are the determinants of attitudes toward the use of technology, which predict behavioural intention and actual use. Effort expectancy is similar to perceived ease of use in the technology acceptance model (Kim, Mirusmonov and Lee 2010). Later, Wu, Tao and Yang (2008) reported that technology's success and acceptance depend on its PEOU. Based on this context, EE can help to restore a student's self-efficacy and make tasks more effortless.

Moreover, the empirical evidence reported numerous learners in developing countries are less exposed to educational information systems or educational technology (Ssekakubo, Suleman and Marsden 2011); this turns out to make EE an important factor in ICT adoption. Performance expectancy and effort expectancy are the predictors of academic staff in the acceptance of technology and use of information technology (Oye, Iahad and Ab Rahim 2013). Based on this, learners are expected to adopt, accept, and use technology. They must understand it before adopting, accepting, and using it. Effort expectancy is the simplicity level of technology Venkatesh *et al.* (2003).

4.7.3 Performance Expectancy (PE)

Performance Expectancy → refers to the degree to which users believe that using technology can improve the execution of the job (Venkatesh, Thong and Xu 2012). In addition, Venkatesh *et al.*

(2003) described PE as the extent to which users using technology believe that it will improve their performance. It is highlighted that the most significant factor influencing BI to use technology is PE because many users believe that using technology has benefits to be gained (Dwivedi *et al.* 2019; Anthony, Kamaludin and Romli 2023). Performance Expectancy in the UTAUT has an identical meaning to perceived use in the TAM (Lee and Rho 2013). In the context of ICT adoption, the employment of PE shows that learners believe that the adoption of ICT will increase the teaching and learning process (Mtebe and Raisamo 2014).

4.7.4 Facilitating Conditions (FC)

Facilitating Conditions → Is a degree to which the user of technology believes that institutional and technical infrastructure exists to support the use of technologies (Venkatesh *et al.* 2003; Gawande 2016). Furthermore, Venkatesh *et al.* (2003) describe facilitating conditions as the extent to which an individual perceives the presence of organizational and technical infrastructure to aid in utilising the new system. Each student is responsible for ensuring that there is essential technology while using technology, such as online help, internet access, and so on (Lakhal, Khechine and Pascot 2013). Accordingly, in the adoption of ICT, the educational sector and government must provide valuable ICT infrastructure to use technology in schools (Anthony, Kamaludin and Romli 2023). Even so, Venkatesh *et al.* (2003) argued that FC is a determinant of technology acceptance. In this study, SI is correlated with FC, while FC is correlated with external variables, such as funding and over-digitalization of education. The following section discusses extending UTAUT with new construct variables.

4.8 The external and internal variables of ICT adoption in the study framework

A study by Kim and Lee (2022) added an external construct educational policy in an original UTAUT model, and the findings demonstrated that educational policy influences teachers' behavioural intention to adopt the technology. It is seen that government policy includes many external constructs, so this study has decided to add new construct variables, such as over-digitalization of education, cognitive barriers, health challenges, time, and funding, to the UTAUT model.

4.8.1 Funding (FUN)

Funding or support → This pertains to the absence of ICT assistance from the government, non-profit organizations, and private enterprises. These include the One Laptop Per Child (OLPC) program from the Non-Profitable Organizations (NPOs) in the United States was initiated to assist more learners from developing countries around the globe. Aruleba and Jere (2022) found that several initiatives are done by the government, NPOs, investors, and private sectors to fund urban areas to support the Fifth-generation wireless (5G) network. However, a program known as One Tablet Per Child (OTPC) supplied 800,000 tablets globally to aid learners in adopting ICT in developing countries; these tablets were distributed to first-grade learners (Tabira and Otieno 2017). As a result of ICT device dissemination, it does not positively guarantee ICT skills (Oyedemi and Mogano 2018). The supply of these devices played a critical role in Kenya. Teachers

and learners are advised to apply to Bring Your Device (BYOD) in schools. Bring Your Device is a typical program that allows teachers and learners to support ICT in schools and the working environment by carrying their own mobile devices to school and work environments for general educational purposes since ICT is a general-purpose technology. This type of BYOD project increases the chances of security threats and challenges due to different security requirements (Wang, Wei and Vangury 2014), protection tools, for example, anti-virus and firewall are needed to protect malicious attacks from the spy.

As aforesaid, the supply of ICT infrastructure does not guarantee ICT skills. So, ICT support is imperative to safeguard the BYOD project in schools. The OLPC project aimed to ensure that every single learner acquires a high-quality education and a laptop at a lower cost and with low power. With this typical equipment, learners can relate to ICT and share information to create a bright future for the youth. The laptop is modelled for poor learners from impoverished families who are struggling to purchase digital devices to embrace technology. It uses less power. The reason for this is no adequate electricity in most developing countries, specifically in the Sub-Saharan Africa (SSA) regions (Leslie Steeves and Kwami 2017; Mihai 2017; Bester *et al.* 2021). This OLPC project shows that developed countries reluctantly support developing countries experiencing obstacles in ICT and embracing ICT in the teaching and learning process. In addition, cooperation with other stakeholders can bridge the gap between less developed and developed countries. This study is trying to reduce this gap between developing and developed countries by identifying factors that hamper the wide adoption of ICT among rural learners in developing countries.

4.8.2 Over-digitalization of Education (ODE)

Education over digitalization has advantages and disadvantages. This section discusses the disadvantages, and future researchers can discuss both. The 4IR highlighted the need for digital transformation, and the coronavirus (COVID-19) pandemic was highlighted as well. In many countries nationwide, the government forced teaching and learning processes to be conducted via satellite to reduce the spread of the coronavirus. Despite these transitions, developing countries were suffering the most due to the lack of ICT infrastructure (Mhlana, Chipangura and Twinomurinzi 2021; Mahlo and Waghid 2022; Ssenyonga *et al.* 2022; Sulistiyo *et al.* 2022; Teye and Duah 2022; Van Greunen and Fosu 2022; Gamit 2023; Matli and Phurutsi 2023; Shala and Grajcevci 2023; Zenda and Dlamini 2023).

The deficiency of satisfaction with modern education customized the mindset of teachers, "integrating ICT in the teaching and learning is a complex process, which different barriers may hinder" Others are not happy with the available ICT resources. Others realize that teachers are not fully prepared for ICT skills (Bakari and Ali 2023). In addition, teachers regard the new teaching style of educational digitalization as "enemies." According to Güneş (2022), digital technology positively contributes to children and ameliorates distinguished typical skills, such as creativity and problem-solving skills; this is reported as a dangerous habit to mitigate children's play process

and slows down the development of genetic origin. If this is, I will be devastated. The over-digitalization of education includes experts from different clusters, such as educational experts, ICT specialists, teachers, learners, policymakers(management, school leaders), and Safonov, Usyk and Bazhenkov (2022).

4.8.3 Health Challenges (HC)

Health challenges → refers to any illness that might affect the adoption of ICT. Developing countries should strengthen ICT integration and health systems to meet medical needs, enlarge the prevention of existing medical ICT resources, and make it feasible for people living in developing countries. Furthermore, in developing countries, the supply and provision of medical resources are the major effect challenges facing their communities (Zhang, Gong and Zhang 2022). So, the supply of medical resources, specifically in developing countries, is the best notion for addressing the ongoing issue of medical resources. Developing countries could invest more in education and prioritize technology to improve the Primary Health Care challenges. A study by Zhang, Gong and Zhang (2022) reported that China faces more challenges in ICT development and medical health resources in rural and urban areas (Zhang, Gong and Zhang 2022).

Educational, technological, economic, and sociocultural factors are reported as factors that impede the adoption of ICT among patients with comorbidities, such as diabetes self-management. Identifying these challenges indicates that if the government can address the above barriers, people with diabetes could be served by the government. The economic factor was reported as a predominant factor by Petersen *et al.* (2020). This challenge is reported as a complex variable that needs to be rectified due to slow economic growth. This aligns with the report gazetted by the World Bank (2024); the economy recorded 36% in the SSA regions between 1990–2021. Zhang, Gong and Zhang (2022) reported that the supply of ICT has improved health issues and revealed that the availability of internet access and mobile phones can reduce the mortality rate. In addition, the government intends to provide broadband internet in impoverished communities to ensure network connectivity and address the issue of diabetes self-management for PHC (Petersen *et al.* 2020). Young people are recognized as “digitally native”; despite this, they find it difficult to use ICT in their health (Liaaen, Ytterhus and Söderström 2023). Moreover, using ICT to engage creates barriers; these barriers are made by a poor fit of personal needs and lack of communication, and novices cannot access robust systems, which can be challenging.

4.8.4 Cognitive Barriers (CB)

There is a feasibility and need for a positive attitude toward digital tools. Despite the deficiency in ICT devices, teachers are impeded from using new technology; moreover, this experience influences attitudes, increases overwork, and ultimately creates cognitive barriers (Buda 2020). Ogundile *et al.* (2019) described cognitive factors as factors that help learners understand, communicate, assimilate, and apply knowledge in the classroom by using ICT infrastructure; mental factors are responsible for the lack of ICT adoption.

A study by Astell *et al.* (2022) reported a clear understanding of the existence of barriers and challenges of the old age group people living with cognitive disability; the independent living support functions for older people integrated 17 ICT devices for the old age group people living with cognitive disabilities, the outcomes of this project yielded positive results for the need of ICT technologies among the old age group people with cognitive impair. Based on this, the introduction of technology is appreciated and accepted in the real world, but with disadvantages and complications, it requires government agencies to step forward with innovations to support people with cognitive and eye impairment.

4.8.5 Time (TIM)

Time → in this study, we refer to the little time allotted for teachers and learners to use technology at schools. Previous studies discussed time as the major factor in the adoption of ICT, with little time allotted for teachers. More time is needed for teachers to cooperate (Gil-Flores, Rodriguez-Santero and Torres-Gordillo 2017). There is a possibility of time to use digital technologies (Buda 2020). Based on this, school leaders could set up extra time that could accommodate teachers to participate in ICT (Gallardo Montes, Rodríguez Fuentes and Caurcel Cara 2023). Payal (2018) and Al-Mamary (2022) reported that the availability of time is a hindering factor that precludes teachers from using ICT tools in schools. Moreover, the time allotted (given) to the teachers does not allow teachers to spend more time, and several reduced timetables were reported as an impediment to the use of ICT in the teaching and learning process.

Many studies reported time restrictions and the failure to organize sufficient time for computer studies in the classroom as a challenge to teacher's use of ICT in the teaching and learning process. The existence of time restriction challenges exist for teachers in many ways of their work as it affect the progress of the studies in schools. A study by Basak and Govender (2015) reported that "lack of time" planning is an impediment factor that inhibits the teaching and learning process in schools and the adoption of ICT in the teaching and learning process. The deficiency of time shows the poor quality of time planning and little allotted time to integrate ICT.

4.9 The advantages of the Extended UTAUT (XUTAUT) framework

Accordingly, this research provides a new model to understand learners' intention toward mobile learning (Alghazi *et al.* 2021). To better understand learners' behaviour on Facebook during the teaching and learning process, this study will enhance UTAUT by adding two additional constructs: hedonic motivation and habit (Escobar-Rodríguez, Carvajal-Trujillo and Monge-Lozano 2014). To better understand any factors, extending the model as previous authors did is important. Alghazi *et al.* (2021) show a diagram of guidelines for successful mobile learning applications based on the study's findings. This study's understanding refers to a better understanding of the extended model.

The UTAUT model, which only considers performance expectancy as a factor, is expanded by incorporating the hedonic motivation construct (Venkatesh, Thong and Xu 2012). This study is

expanded by incorporating the top five principal components or factor analysis constructs, for example, over-digitalization of education, cognitive barriers, health challenges, time, and funding. These variables include both internal and external variables (see Figure 4.3) in the study model. Extrinsic refers to the external variables, while intrinsic focuses on internal variables.

Batucan *et al.* (2022) expanded the UTAUT model in the paper to include enjoyment, interactivity, flexibility, and quality. It was suggested that these factors may vary in developing economies. The study found that the model had strong internal consistency and reliability, suggesting it could effectively explain the subject matter. Quality refers to the standard of the proposed model and how good is the technology adoption; flexibility refers to the ability to change easily of an extended model; interactivity the involvement of the user with technology adoption; enjoyment refers to the feeling of admiring technology adoption, reliability how user relies on technology and means constancy and accuracy.

One of the reasons why online users are at risk when making purchases or transactions is their lack of knowledge of technology. Fortunately, a new framework has been implemented to reduce this risk significantly. This improved framework provides online customers with a more competitive and attractive platform both locally and internationally. It also enables vendors and buyers to engage in more information-based transactions Alshannag *et al.* (2022). Reduce risk refers to the reduction of five hindering factors affecting the wide adoption of technology among learners in rural secondary schools in developing countries. The integrated models could provide more explanation than a single model. Research using our integrated model should lead to a better understanding of IT choices. Dishaw and Strong (1999) conducted an empirical study on extending the TAM with TTF; the results indicated that extending models provides a better understanding than either model alone. Many studies have implemented extended model perspectives (Shih and Chen 2013).

4.10 The selection and justification for extending the UTAUT over TAM and TTF

The previous sections have often declared studies and theories in adopting technology and reported disparities of such studies in developing countries. In those mentioned above, it is inevitable and clear that TAM has been widely used in technology acceptance in developing countries around the globe. Even though these prominent models are lambasted for their low explanatory power of the two endogenous variables, for example, behavioural intention and use behaviour by explain almost 30% to 40% only (Venkatesh *et al.* 2003). The integrated acceptance paradigm UTAUT was used in previous studies heightened and explained almost a powerful explanation, amounting to 70 per cent (Venkatesh *et al.* 2003).

The UTAUT model (paradigm) is an empirically validated model that includes eight major models of TA and their extensions. Even though the UTAUT model is a new paradigm compared to TAM since its establishment in 2003 by (Venkatesh *et al.* 2003), researchers are increasingly exploring

the suitability, validity, and reliability of technology adoption in various contexts (Venkatesh *et al.* 2003; Oshlyansky, Cairns and Thimbleby 2007). Previous studies, for example, Namahoot and Jantasri (2023) used the UTAUT paradigm in cashless payment systems to mediate perceived risk and trust in Thailand. Their results validated that the UTAUT model, perceived risk, and trust all significantly impact individuals' decision to use a cashless payment system. This implies that consumers in Thailand are more likely to embrace a financial, or technological innovation if they feel that the associated risks are low. They can trust the system, particularly if it is integrated with a dependable online banking network. Guillén-Gámez *et al.* (2024) in teaching digital competence in the use of YouTube and its incidental factors based on the UTAUT model using the partial least squares structural equation modeling (PLS-SEM) approach validated that the research highlights the importance of enhancing teachers' digital competencies, with a focus on behavioural intentions to improve the use of YouTube as a tool.

The findings validated that the digital proficiency of teachers is a complicated system where multiple factors influence the successful functioning of a particular educational technology. Therefore, a proper infrastructure alone is not sufficient, as the simultaneous development of Behavioral Intention is also necessary. Shaya, Madani and Mohebi (2023) developed and tested the theoretical model to speculate factors affecting learners acceptance and behavioural intentions to use m-Learning by applying the extended UTAUT model with supplementary constructs, for example, service quality, perceived enjoyment, mobile self-efficacy, and satisfaction. The results reported that (a) Behavioral intention was outstanding and positively affected by satisfaction, (b) PE and EE were positively related to satisfaction, and (c) perceived enjoyment, service quality, and mobile self-efficacy had a positive effect on performance expectancy and effort expectancy.

The UTAUT model is the most comprehensive because it combines about eight theories. For example, the theory of research action (TRA), TAM, the motivational model (MM), the theory of planned behaviour (TPB), a combination of TAM and TPB, the model of principal component utilization, the innovation diffusion theory (IDT), and social cognitive theory. UTAUT synthesizes eight theoretical models from psychology and sociology to explain technology adoption (Venkatesh *et al.* 2003). So, this study has decided to use four main constructs of the UTAUT social influence, effort expectancy, performance expectancy, and facilitating condition. Based on the findings in Table 4.6, this study could not use TAM and UTAUT alone. Hence, could use UTAUT plus extended model to alleviate the problems. In Table 4.6, TAM and UTAUT reported seven marks. The TAM reported three marks advantages, while the UTAUT reported four marks. Based on the comparison of the TAM and UTAUT models, this study has decided to use UTAUT with four marks instead of TAM.

Despite its limitations, UTAUT has high explanatory power and can account for 70% of the variance in the behavioural intention construct (Alshammari and Rosli 2020). Additionally, UTAUT is a more robust model as it has an explanatory power of up to 70%. This is compared to

previous models that only account for between 17% and 53% of the variance in use intentions (Venkatesh *et al.* 2003). Even though the UTAUT could not solve the adoption of ICT alone, it needs to be extended. Notably, this model fails to account for crucial factors such as attitude, anxiety, and self-efficacy, which are natural components of intention. Moreover, attitude toward technology use does not necessarily directly influence intentions (Raza *et al.* 2021). This study could add to the over-digitalization of education, cognitive barriers, health challenges, time, and finally, funding from the principal component analysis diagram in Dimension 1 to measure technology adoption among learners in developing countries.

In 1986, Davis in a dissertation, hypothesized that a user's attitude towards using a system is a major factor in determining whether they will use or reject it. Despite what Davis hypothesized, previous research indicates that attitude is not a full mediator between PU and BI, implying that the model may exclude attitude (Davis and Venkatesh 1996; Venkatesh 2000). This aligns with a study by Davis, Bagozzi and Warshaw (1989) which reported that attitude only partially affects perceived usefulness and perceived ease of use in behavioural intention. Cruz-Cárdenas *et al.* (2019) contend that a user's attitude plays a crucial role in determining their behaviour toward technology usage.

Even though TTF was applied in this study, the researcher decided to use UTAUT. The task technology fit is described as the extent to which technology aids in completing tasks (Goodhue and Thompson 1995). Task technology fit has many limitations, such as the complexity of the model, low power predictive, and deficiency of focus on personal factors (Papagiannidis 2022). Furthermore, the original TTF model's limited applicability stems from its multi-dimensional constructs. There are not many studies that have tested the TTF model. The limitation of studies created an argument of not considering cognitive barriers on individuals to gain trust in the acceptance of information systems or information technology in the globe. The TTF theory has a major limitation in that it only considers the current moment of fit. As tasks evolve and become more demanding over time, the technology may not have the necessary features to assist users, which can cause technostress (Vendramin, Nardelli and Ipsen 2021). Task technology fit has been lambasted for not considering the individual technostress of the user. Often, users feel lonely because they do not consider necessary features in the adoption of IS/IT. So, it requires strenuous effort to deal with technostress due to the insufficient TTF features.

Furthermore, in the task-technology fit model, the task characteristics do not influence the task-technology fit model and hence have a finite impact on employees' performance. Government procedures can restrict the TTF characteristics. The TTF model “may not address all constraints”, needs progressive updates for success, and adds alterations (Kim *et al.* 2015; Chen, Chen and Tsai 2022). However, this model did not create high learning performance in information technology systems or affect learners' satisfaction (Yuce, Abubakar and Ilkan 2019). On this, the researchers have decided to ignore the use of the task-technology fit model, as many authors ignore the use of the TTF-UTAUT model.

However, end-user adoption behaviour factors were not adequately addressed by TTF-UTAUT (Eybers *et al.* 2019), and individuals were psychologically left behind. So, this study has decided to consider the cognitive barrier in the UTAUT to reduce the exclusive individuals' psychological factors. Despite the lack of the challenges mentioned above, TTF is not of high quality when it is concatenated (TTF-UTAUT) with UTAUT to measure the acceptance of technology in education. TTF-UTAUT is recommended for user payment systems (IS/IT), not for the educational sector. The TTF-UTAUT paradigm, which was used to examine mobile payment intention in Korea and China, reported that the model is suitable for predicting consumer behaviour in China (Papagiannidis 2022). Therefore, based on this finding, it is not the best way to apply the TTF-UTAUT model in this study.

This chapter explored the literature to examine and exhibit essential technology acceptance models, such as TAM, TTF, DOI, and UTAUT. However, this study could not adopt TAM through the lens of Davis and Venkatesh (1996); Venkatesh (2000) hypothesized the exclusion of attitudes toward the use of technology. Therefore, this study could decide to adopt the UTAUT instead of TAM. In addition, after carefully analyzing the arguments presented in this section and reviewing the existing literature, the researcher has concluded that the UTAUT model is the most suitable model to be adopted for this study. This study investigates the factors affecting the widespread adoption of technology among rural secondary learners in developing countries. The researcher plans to collect empirical data from previous literature to comprehensively understand the challenges.

Table 4.6: A Data Comparison Of TAM, UTAUT, TTF and XUTAUT Models.

Number		TAM Factors	TAM	UTAUT	TTF	XUTAUT
1		Perceived usefulness	✓	×	×	×
2		Perceived ease of use	✓	×	×	×
3		Behavioural intention	✓	×	×	×
		UTAUT Factors				
4		Social influence	×	✓	×	✓
5		Effort expectancy	×	✓	×	✓
6		Performance expectancy	×	✓	×	✓
7		Facilitating condition	×	✓	×	✓
		TTF Factors				
8		Task characteristics			✓	
9		Technology characteristic			✓	
		XUTAUT Factors				
10	A.	*Internal Variables*				
11		Health challenges (HC)	×	×	×	✓
12		Cognitive barriers (CB)	×	×	×	✓
13		Time (TIM)	×	×	×	✓

	B.	*External Variables*				
14		Over-digitalization of Education (ODE)	×	×	×	✓
15		Funding (FUN)	×	×	×	✓

Abbreviations of the constructs of TAM and UTAUT paradigms: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Behavioral Intention (BI), Social Influence (SI), Effort Expectancy (EE), Performance Expectancy (PE), Facilitating Condition (FC).

4.11 Chapter Summary

The Principal Component Analysis (PCA) presented in chapter three was implemented to analyze and visualise data in a different format. This chapter revealed evaluation experiments, outcomes, and descriptions of various models applied in this study, such as TAM, TTF, and UTAUT paradigms. This study experiment was conducted based on the extant literature of the dataset analysed in the scree plot. The PCA contribution diagram ranked attributes, and communality were used to visualize the dataset to interpret models. A total of three figures and seven tables were engineered and scrutinized to measure the amount of data implemented in this study. Moreover, the contribution of each model was compared for validity.

The results of PCA are extremely motivating, and there is an improvement in the adoption of information and communication technology among rural secondary learners. The launch of the study framework revealed positive results in the comparison of TAM, TTF, and UTAUT models. The following section will expound on the summary and conclusion of this thesis based on the discussion of previous chapters.

CHAPTER 5 : SUMMARY, CONCLUSIONS, AND IMPLICATIONS OF THE STUDY

5.1 Introduction

In closing of this dissertation, this chapter sums up part of this thesis, including an overview of the conducted, contribution to knowledge, and possible improvements for future work based on the study approach. The primary aim of this study is to ascertain the core factors hampering the widespread adoption of ICT in rural areas. As no study is ever one hundred per cent perfect, the contribution and future work for improvement are highlighted.

5.2 Chapter Summary

In this study, the top five factors influencing the widespread adoption of Information and Communication Technology (ICT) among rural secondary learners schools in developing countries were investigated, pre-processed, visualized with principal component analysis, and tested for validity with a keen of providing feasible solutions that will enhance the pursuit of challenges of ICT adoption in rural areas. The overarching aim of this study was to identify cogent factors that hamper the widespread adoption of ICT among rural secondary learners in developing countries. So, based on the findings of this study, the researchers genuinely believe that this study has accomplished the main aim of this study. The main objectives of this study have been rigorously satisfied to attain the study aim and objective, and the research question is answered. These are reiterated in the following sections. These objectives were satisfied by identifying cogent factors in Dim 1, ranking factors using Principal Component Analysis (PCA), developing the Extended Unified Theory of Acceptance and Use of Technology (XUTAUT) framework, and their relationship with the ubiquitous adoption of ICT. They are rephrased below to conclude this study as follows:

I. *To comprehensively review and identify cogent factors that deter the widespread adoption of ICT among rural secondary schools from the literature.*

   The results of the first objective of this study were illustrated in Chapter Two (literature review) where all the significant studies were highlighted to support and motivate the necessity of the study. The significant factors were identified through the systematic literature review in Chapter Three (research methodology). Chapter Two presented the role of access to ICT infrastructure, the benefits of ICT adoption, ICT theory models, the role of ICT inside the classroom, the influence of teachers and parents, and factors of ICT adoption. The current trend of improving factors affecting the widespread adoption of ICT was highlighted. The main focus was on the techniques proposed in the extant literature by identifying their strengths and stumbling blocks. The improvement of ICT adoption in rural areas is a huge problem. Despite the development, and implementation of new solutions,

this challenge of ICT adoption continues to increase in developing countries. So, the trend of these challenges in different paths gains significant access among learners at large. Moreover, this trend motivated the researcher to develop a new framework to enhance the adoption of ICT.

II. *To rank the identified factors based on their importance using principal component analysis.*

Chapter Four again identified factors ranked in Figure 4.2 using PCA; the ranked attributes and contributions are outlined. So, based on Figure 4.2, a range from 50 to 70 per cent was opted. Even though attributes recorded less than 50 per cent were shown in Dimension 1 and 2 tables.

III. *To develop a framework to aid the widespread adoption of ICT among rural secondary schools.*

In Chapter Four, the third objective was met by validating or comparing the study framework (proposed model) against the prominent models' TAM, TTF, and UTAUT usually applied in the use, acceptance, and adoption of technology. This chapter presented the analysis of comparative analysis achieved and discussed in terms of comparison of the three existing models that were compared in Table 4.6. The comparison was based on the benefits and barriers of the models. then, three prominent models were applied in the comparison process. Furthermore, the inclusion of over-digitalization of education, funding, health challenges, cognitive barriers, and time constructs added significant inputs in the development of an extended model. A total number of models were highlighted in this study, but the data comparison of TAM, TTF, and UTAUT models was very interesting. Even though, the UTAUT model presented better results during the comparison. More essentially, the comparison of these models confirmed the application UTAUT model to develop a study framework with an inclusion of construct variables from Scopus and Web of Science databases. In addition, the study framework was developed to improve the trend of factors affecting the widespread adoption of ICT among rural secondary school learners in developing countries. Consequently, the development of the study framework is to understand the third objective of the study.

IV. To perform a comparative analysis of the new framework’s construct against the state-of-the-art ICT adoption framework

Finally, an extended framework was developed in Chapter Four, Figure 4.3, based on the combination of the UTAU model and the study's top five findings (factors). In addition, the XUTAUT framework included health challenges that could assist in health issues. Furthermore, it

can contribute to identifying health challenges. In ICT learners, it is essential to promote their physical, mental, and emotional well-being, as well as their academic performance and long-term health results. By prioritizing student health and wellness, schools create a supportive and inclusive learning environment that fosters the holistic development of every student, even in rural areas. By addressing cognitive barriers, the cognitive barrier often requires personalized support, accommodations, and interventions tailored to the individual's specific needs and strengths. By recognizing and addressing these challenges, learners and support professionals can help individuals overcome cognitive barriers and achieve their full potential and time; by prioritizing sufficient time for ICT classes, schools can maximize the benefits of technology integration in education, empowering learners and educators to harness the full potential of digital tools and resources for teaching, learning, and innovation.

Over-digitalization of education can contribute to efficiency and productivity, and digital systems can streamline administrative tasks for teachers, such as grading and lesson planning, allowing them to allocate more time and energy to teaching and student support. Not all learners have better access to ICT infrastructure and high-speed internet at home, leading to disparities in learning opportunities. So, over-digitalization may exacerbate these inequalities if it assumes universal access to technology. The funding of ICT schools is an investment in the future of education, empowering learners and educators with the tools, resources, and skills they need to thrive in a digitally driven society. It also improves educational results; integrating ICT into teaching practices has been shown to enhance student engagement, motivation, and academic performance. Interactive learning platforms, educational software, and multimedia tools can cater to diverse learning styles and facilitate personalized learning experiences. Moreover, other stakeholders, such as the private sector, could try to dominate rural schools.

5.3 Contribution of study

The study target is that the proposed thesis will bridge the gap in the area of the study by developing a new framework (XUTAUT) to solve the ongoing challenges of ICT adoption in developing countries. The primary aim, objectives, and research question are: what factors affect the ubiquitous adoption of ICT among rural secondary learners in developing countries? The main contribution of a new framework (XUTAUT) was designed in this study to:

1. Demonstrates the effectiveness of the top five factors influencing the widespread adoption of ICT.
2. The adoption of reliable quantitative variables to identify correlation metrics, test in a design research approach, and apply four well-known statistical evaluation metrics, for example, eigenvalue, cumulative variance, percentage of variance, and p-value.

3. To develop an effective Extended UTAUT framework to help identify internal and external factors affecting technology adoption in rural schools. The UTAUT model was selected

and merged with the top five influencing factors of ICT adoption to develop an extended framework called XUTAUT. The development of this framework was to identify exogenous and endogenous variables that will aid in ameliorating educational settings in developing countries.

4. To validate a study framework. Different studies used TAM, TTF, UTAUT, and XUTAUT models ticked in Table 4.6 to select the best model compatible with this study. For the selection of the UTAUT, it has more ticks (✓); by contrast, TAM and TTF reported fewer ticks. Therefore, this study highlighted the XUTAUT model with the combination of UTAUT and XUTAUT variables as the best candidate for this study.

5.4 Aligning findings to literature

This section aligns the findings of the study with extant literature and involves comparing and contrasting this study or observations with existing studies and theories to validate the results.

The alignment of the study findings with the literature could ensure that this study is grounded in existing knowledge, contributes to ongoing discussions, and highlights areas for further inquiry. This study expounded on overarching factors affecting the widespread adoption of ICT among learners. After following the thesis structure, over-digitalization of education, funding, health challenges, cognitive barriers, and time constrain were identified as critical challenges affecting the widespread adoption of ICT among rural secondary school learners.

Over-digitalization of education (ODE) in rural secondary schools (RSSs) entails different challenges. While ODE can enhance learning opportunities, their integration in rural settings often faces specific obstacles. This is consistent with a study by (Skobeltsina, Beshenkov and Kuznetsov 2021; Bolshunova, Grigorieva and Maslova 2022; Budhia and Behera 2023; Ramamoorthy, Ramamoorthy and Samayan 2024) found that challenges of ODE in secondary schools decline the interest in studies. It is unavoidable that funding (FUN)-support is required to ensure ODE, adoption and accessibility of technology in schools. The reason for that, technology is administering the way learners learn in schools. Even though lack of funding or support from the government, and private sector affects the teaching and learning process, this is validated in a study conducted by Warioba *et al.* (2022) community schools in rural areas of Tanzania struggled with support to adopt ICT effectively. Lack of funding affects the teaching and learning process (Jacob, Jegede and Musa 2020; Njoka, Githui and Ndegwa 2020; Tsimba, Mugoniwa and Mutembedza 2020; Warioba *et al.* 2022). These are extrinsic factors. However, intrinsic factors such as health challenges, cognitive barriers and time restrict the adoption of ICT as well.

The adoption of ICT in schools provides numerous benefits, but it also gives plenty of health challenges. These challenges affect both the effectiveness of ICT and the well-being of learners using ICT infrastructure. According to Mansour Ali and Mohammed (2024), secondary school learners are exposed to different health challenges such as “uncomfortable bad body mechanics (94.3%), low concentration (91.3%), general body weakness (92%), vision impairment (68%)

hearing (67.4%), and there is a significant relation between levels of education and use of digital technology". Furthermore, cognitive barriers are an influential factor in ICT adoption (Buda 2020; Ferdousi 2022). Not considering the two intrinsic factors alone, time (TIM) affect the effectiveness and efficiency of adopting ICT into education. This is compatible with this, merely 85% of RSSs spend 1-5 hours daily on e-learning in India (Ramamoorthy, Ramamoorthy and Samayan 2024). Moreover, " limited time due to demands" affects the adoption of ICT among RSSs (Dutta and Hazra 2023).

Ways forward for the adoption of ICT in RSSs, the Department of Basic Education and policymakers need to focus on the improvement of ODE, FUN, HC, CB and TIM.

5.4 Conclusion

This study has identified the top five principal factors that affect ICT adoption among rural secondary school learners in developing countries. These factors were identified from the dataset analysis using the principal component analysis. Information and Communication Technology (ICT) adoption in developing countries will improve if policymakers, Departments of Basic Education, and the private sector study and address the reported predominant factors. As discussed, developed countries are not left behind in information and communication technology. So, developing countries cannot afford the proceeding lag behind while other countries in information and communication technology adoption and usage are effective.

These factors are acting as impediments to the influence of ICT adoption in developing countries are over-digitalization of education, funding, health challenges, cognitive barriers, and time which have contributed to other problems such as lack of ICT infrastructure, lack of ICT skills, deficiency of internet access, shortage of modern software, stereotype, administrative, anxiety and so on. Some of these challenges are caused by the government's cutting off electricity and not disseminating sufficient power in rural areas, which causes a breakdown of computers. Also, poor internet quality is caused by power outages, and so many influence the adoption of ICT in developing countries. This is similar to the study "Outbreak of Online Learning in Sub-Saharan Africa" by (Adarkwah 2021) in Ghana. The Sub-Saharan African regions need to consider the issue of power outages. Addressing the progressive challenges among rural learners living in developing countries could be essential to help learners properly prepare for employment, Education 5.0, and entrepreneurship, thereby mitigating unemployment and fast-tracking the nation's quest to achieve positive results in schools.

5.5 Future works

Despite the identification of influencing factors, there is room for improvement and innovation. The findings of this study could be used by policymakers and the Department of Basic Education to improve educational settings. However, there is a possibility that the pandemic might take place in the future. Moreover, the Fourth Industrial Revolution (4IR) is passing now, so a new

technology is coming shortly: Education 5.0. So, understanding these different factors affecting the widespread adoption of ICT can improve and prepare for the future, and plenty of challenges can be circumnavigated when there is a need to address reported influencing factors. This is a mini step towards more steps that need to be taken to improve the educational domain. Several challenges to ICT adoption in the educational context are persistent, so to circumnavigate the ongoing challenges, this study implies the different steps to be followed in making this study go beyond.

1. Future studies can collect primary data from the learners, educators, and other stakeholders for comprehensive innovation. This study used PRISMA procedural guidelines, so collecting primary data to obtain various perspectives is advisable.
2. Further researchers can employ different methodological frameworks with various steps, not the design research approach with the pre-processing, codification, principal component analysis, and comparative analysis. This study suggests that future researchers can apply different approaches, such as interviews, surveys, questionnaires, etc.
3. As a result of these findings, future studies can investigate more about why over-digitalization of education, funding, health challenges, cognitive barriers, and time have a colossal effect on the adoption of ICT among far-flung rural secondary schools in developing countries. It may be how the program is run; it could be an issue of policymakers and the Department of Basic Education.

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