INFLUENCE OF PERSONAL AND SCHOOL LEVEL FACTORS ON INTEGRATION OF INFORMATION COMMUNICATION TECHNOLOGY IN BIOLOGY TEACHING IN PUBLIC SECONDARY SCHOOLS IN KIAMBU COUNTY, KENYA

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A Research Thesis Submitted to Graduate School in Partial Fulfillment of the Requirements for the Conferment of the Degree of Doctor of Philosophy in Educational Management of Laikipia University.

JULY, 2025

DECLARATION AND RECOMMENDATION

Declaration

I confirm that this research thesis is my original work and has not been presented wholly or in part for an award of a degree or any other award in this or any other University.

Signature…… Date……

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Recommendation

This thesis has been submitted for examination with our approval as University Supervisors

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DEDICATION

To my beloved family. Alice, Angelah, Lewis, Annah and Celestiah.

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Abstract

Education worldwide is increasingly integrating Information Communication Technology (ICT) to enhance teaching, learning, and school management. Failure to adopt ICT in the 21st century risks undermining the quality of education. This study examined the extent to which personal and school-level factors influence the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. Specifically, it investigated the role of teachers' gender, age, competency, and teaching experience, as well as school-related factors such as availability of ICT resources, principals' supervision, maintenance of ICT facilities, school size, and school category. The study was anchored on the Technological Pedagogical Content Knowledge (TPACK) framework, Constructivist Theory, and the Diffusion of Innovation (DOI) model. An ex-post facto research design was employed targeting 812 respondents (521 biology teachers and 291 principals). A sample of 260 participants (167 teachers and 93 principals) was selected using stratified, purposive, and simple random sampling techniques. Data was collected through questionnaires. Analysis was conducted using both descriptive and inferential statistics with SPSS version 26. The findings revealed that teacher competency, teaching experience, availability of ICT resources, and maintenance of ICT facilities significantly influenced ICT integration. However, teachers' gender, age, principals' supervision, school size, and school category showed no significant effect. The study recommends that Boards of Management induct new teachers on ICT integration, the Teachers Service Commission (TSC) motivate teachers to undertake ICT-related courses, and the Ministry of Education allocate adequate funds for ICT maintenance and provision of ICT resources to public schools.

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ACRONYMS AND ABBREVIATIONS

ANOVA : Analysis of Variance

AU : African Union

BBC : British Broadcasting Corporation

BECTA : British Educational Communications and Technology Agency

B.Ed : Bachelor of Education

BoM : Board of Management

CBC : Competency Based Curriculum

CBE : Competency based Education

CCTV : Closed Circuit Television

CD : Compact Disc

CD-ROM : Compact Disk Read Only Memory

CESA : Continental Education Strategy for Africa

CEM : Curriculum and Education Management

CEMASTEA : Center for Mathematics, Science and Technology Education in Africa

CEO : County Education Office

CUE : Commission for University Education

DLP : Digital Light Processing

DOI : Diffusion Of Innovation

DVD : Digital Versatile Disk

DVD-ROM : Digital Versatile Disk Read Only Memory

FY : Financial Year

FDSE : Free Day Secondary Education

GDP : Gross Domestic Product

HoD : Head of Department

GoK : Government of Kenya

ICT : Information Communication Technology

IJEDICT : International Journal of Education and Development using ICT

IM : Instructional Materials

ISP : Internet Service Provider

IRI : Interactive Radio Instructions

IT : Information Technology

IWB : Interactive White Board

KICD : Kenya Institute of Curriculum Development

KCPE : Kenya Certificate of Primary Education

KCSE : Kenya Certificate of Secondary Education

KEMI : Kenya Education Management Institute

KESSHA : Kenya Secondary Schools Heads Association

KESSP : Kenya Educational Sector Support Programme

KNEC : Kenya National Examination Council

LCD : Liquid Crystal Display

LCOS : Liquid Crystal on Silicon

LED : Light Emitting Diode

MEd : Master of Education

MoE : Ministry of Education

MoEST : Ministry of Education Science and Technology

MoHEST : Ministry of Higher Education Science and Technology

MS : Microsoft Software

NACOSTI : National Commission of Science, Technology and Innovation

NEMIS : National Education Management Information System

NGO : Non-Governmental Organization

PA : Parents Association

PC : Personal Computer

OER : Open Educational Resources

PDA : Personal Digital Assistance

PC : Personal Computer

PhD : Doctor of Philosophy

PQ : Principals Questionnaire

PWPER : Presidential Working Party on Education Reform

QUASO : Quality Assurance and Standards Officer

SD : Standard Deviation

STIC : School of Technology and Innovations Center

SMASSE : Strengthening of Mathematics and Secondary Science Education

SME : Subject Matter Experts

SoE : School of Education

SPSS : Statistical Package for Social Sciences

TPACK : Technological Pedagogical Content Knowledge

TPB : Theory of Planned Behaviour

TPAD : Teacher Performance Appraisal and Development

TQ : Teachers' Questionnaire

TSC : Teachers Service Commission

UNESCO : United Nations Educational, Scientific and Cultural Organization.

US : United States

USAID : United State of America International Development

VCE : Video Conference Equipment

WGMSE : Working Group on Mathematics and Science Education

OPERATIONAL DEFINITION OF TERMS

Availability of ICT : ICT at disposal for teachers to use in class to deliver content.

Constructivism : An active construction of new knowledge based on a prior experience or existing schemas.

Hotspot : Wireless access point that let an individual connect ICT devices to the internet.

Influencing : Affecting either positively or negatively or both.

Information Communication And Technology (ICT): Form of technology used for creating, displaying, storing, manipulating, and exchanging information among users

Maintenance : A process of preserving ICT devices in good working condition in a school for use by the teacher

Supervision : Process of critical watching of the teachers in a school done by the principal or his/ her appointee.

School category : Classification of public schools according to entry behaviour of the learners. Such that the school is classified as Sub-County, County, Extra-County or National

School size : Division of public secondary schools depending on the number of students admitted in the school at a particular time such as a year

Teacher competency : Confidence, skill, and capability in using ICT for instruction purposes, leisure and communication by the teacher to perform the task appropriately.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Information Communication Technology (ICT) is a general term that includes computer hardware, software and audio - visual systems which enable users to create, access, store, transmit and manipulate information (Prasad & Chakravarty, 2020).). Amutha (2020) defined ICT as an umbrella that includes any communication device or application, cellular phones, computer and network hardware, software, satellite system and video conferencing facilities. Arthar-Baidoo et al. (2022) on the other hand defined ICT as tools used to transmit, store and retrieve information by users. Li et al. (2018), observed that ICT are items used in day-to-day communication in order to relay messages, store and help to retrieve effectively and efficiently. Such items include computers, printers, phone, television, radio, projector and any accompanying hardware and software. Therefore, ICT can be said to be a term that refers to tools used for communication to receive, store, process and retrieve information. Such tools include computers, mobile phones, internet, television, hardware and software that accompany them.

According to Bennis (2022), studies on the use of ICT in teaching has been done in various regions of the world. Romero-Hall (2021) in a study conducted in Latin America, found that there was a huge digital divide between urban and rural area schools. The study categorized factors influencing integration of ICT into infrastructural and human. Carter and Grover (2015) in their study on integration of computers in secondary schools in South America found out that there were two common factors that influenced integration of ICT. The two factors were inadequate computers in the classroom and inadequate time to learn how to incorporate the computer into the curriculum. As a result, many teachers did not integrate ICT into their teaching mainly because the facilities were inadequate. An intensive study in United States (US) secondary schools identified mismatched rates of change, unrealistic expectations

by teachers, teacher's competency, and mismatch of resources as influencing factors to ICT integration (Amini & Oluyide, 2020). Reiser and Salisbury (2015) identified a number of factors that influence ICT integration in American schools. These researchers cited availability of hardware, software and funding as one of the major constraints to technology integration. The researchers further argued that time for planning; personal exploration, online access, and skill development were a limiting factor.

Lastly, the researchers noted that technical, administrative support and resources hinder proper integration. Reiser and Salisbury concluded that integration does not just happen in a vacuum but it is influenced by a score of factors that may accelerate it or slow it down. Others studies in united states have pointed to the practical constraints operating within the working contexts in which teachers currently find themselves. A study by Niederhauser et al. (2018), indicated that integration in United States is costly in terms of time and required experience of the teacher who is the user. This means that developing effective pedagogy around ICT involves significant input in terms of planning, preparation and follow-up of lessons. Karna et al. (2022), did a study in North American senior schools and found that availability of ICT equipment and facilities is a key determinant of integration of ICT in teaching. Irvin et al. (2018) in their study done in United States concludes that supervision is essential to see that integration of ICT is done in senior schools. Their study identified factors influencing integration as either institutional and human. A study on influence of school size on integration of ICT in United States of America by Cotton (1996) reported that public secondary schools are allocated resources according to the number of students enrolled.

The study further postulates that large schools with many students receive more funding and teachers by ratio of students to cater for large curriculum areas offered. This supported findings by Saidin and Brahim (2013) who posited that categorization gives advantages to some categories while disadvantaging others especially the least among the categories. Pont (2020) did a study in America that looked onto the school size and its influence on school activities such as teaching. The study by Pont postulates that school size has an effect of use of ICT in American districts schools. In support, Luyten et al. (2014) notes that the size of a secondary school in America has an influence on utilization of resources. A study by Kennedy and Cronje (2023) found that large schools have good per pupil operational cost hence are cheaper to operate as compared to small schools that have poor funding and poor per student allocation of resources. Rice-Stevenson (2022) posits that large schools in US avail more

teaching resources due to economies of scale associated with administrative costs. Luyten et.al. (2014) supports that fact that school size has influence on integration by concluding that large schools in America receive huge state funding as compared to small state schools.

A study in East- Asia by Li et al. (2018) depicts that schools have invested a lot in ICT for use in administration, teaching and assessment. The study observed that in Mongolia, the factors influencing Integration of ICT were dichotomized as 'institutional' and 'personal' with 'personal' factors such as experience of the teacher, technical skills, gender, competency, qualification, age and confidence viewed as particularly more influential. The institutional factors included the school category, school size, supervision of teachers, maintenance of ICT tools and preference by administration among others. Sayo (2016) did a study in Japanese secondary schools and reported that there are several factors affecting integrating of ICT. The study noted that proper maintenance of ICT resources is a key factor influencing integration in teaching in secondary schools. Sayo (2024) in a study on utilization of ICT in Japanese high schools in post- COVID era, concluded that there are two major factors affecting the process of integration. The two factors identified were external (first-order) and internal (second order) barriers to utilizing ICT. The study noted that the strongest barriers were second order barriers specifically technology-related classroom management skills such as teacher competency.

Sayo (2024) posits that maintenance of resources is essential for their proper utilization. Infact, when ICT resources are availed for use in school, they also need to be maintained so that they can in good condition for use by the teachers. According to Cheok et al. (2020) integration of ICT in secondary schools in Malaysia has been influenced by insufficient hardware, lack of adequate software, obsolete resources and lack of support services to the teachers. They further adds that, inadequate time, gender, age of the teacher, un-appropriate reward system, lack of information about good practice and underestimation of the difficulty in adopting new information technology could also influence integration of ICT in teaching. A study in Taiwan by Ting and Chuang (2024) affirms that principal's supervision could also be a factor that influences use of resources for teaching and apparently integration of ICT in teaching. The study reported that the principal is responsible for the overall running and controlling of the school and maintenance of standards through supervision. Julianda et al. (2024) did a study in Indonesian junior high schools and confirms that effective academic supervision by the principal is essential in fostering teacher professionalism and enhancing

educational quality. A study in India by Das (2019) observes that although so much has been done in India to increase the technological infrastructure in schools, institutions are far short of providing a robust and reliable technology support structure for all students and teachers. The study observed that integration of ICT in Indian secondary schools was not fully done and many schools lacked basic ICT facilities which influenced their integration.

According to Li (2025), the integration of ICT in Australian secondary schools is greatly influenced by the proficiency and attitudes teachers towards ICT among other factors. In this study it has been reported that pre-service teachers may face some challenges in their integration of ICT. In New Zealand, a study by Santamaria et al. (2023) revealed that integration of ICT in education was being influenced by state funding which was anchored in size of the school among other factors. Zanchi and Watson (2024) in their study in Aotearoa, New Zealand found that gender of the teacher significantly influences use of technology in education. The study concluded that gender is a key factor influencing integration of ICT in senior schools in New Zealand. Dirin et al. (2019) did a study in Finland and noted that non-integration of ICT in education was a matter of social and psychological factors. In addition, the study found that inadequate administrative support and the value a person places on the innovation affects integration of ICT in teaching. Dirin et al. therefore postulated that integration of ICT in teaching in Finland was influenced by a number of factors. The key factors identified were gender of the teacher, age, attitude of teacher, location of the school and category.

Turgut, and Aslan (2021), did a study on integration of ICT in Turkey. They found that ICT integration into learning environments in Turkey was affected by five factors; students, educational material, infrastructure, management, and teachers. They added that the factors can simply be classified as teacher related or school related. Schmitz et al. (2022) did a study in European secondary schools and looked at barriers affecting integration of ICT. Their research study grouped these barriers into two broad categories: first-order barriers, related to external factors such as access to technology and equipment; and second-order barriers, related to internal factors such as skills of the school members. The study noted that second-order barrier has a greater influence to integration of ICT in schools.

Pisa (2025), did a study in German schools and concluded that gender is a major factor that influences integration of ICT in teaching across all levels of schools. Altun and Yengin (2020)

did a study in Turkey and describes school supervision as the process of bringing about improvement in instruction by working with people (teachers) who are working with students. Their study posits that use of ICT for teaching is influenced by both school based and teacher based factors. Their study concluded that principals' supervision in secondary schools is essential for integration of ICT resources. Eisenkopf et al. (2015) did a study on influence of gender and categorization on resources in Germany and concluded that secondary schools are categorized world over. The study posit that the categorization has consequences on utilization of computers for teaching.

In Africa, a study looking at the influence of age on integration of ICT in Morocco by Bennis (2022) reported that there is a myth on generational gap in relation to ICT use such that the young generation of teachers are said to be 'digital natives' in contrast to the older teachers who are said to be 'digital immigrants. Bennis' study confirmed this as truth and in this view, a solution to the problem lies in the generational change where young teachers are expected to be better adopters and users of the new technologies and therefore the instruments for bridging the digital gap among populations. Yassin (2024) did a study in North Africa and found that inadequate teacher training and the unavailability of technological infrastructure were major factors influencing integration of ICT in the teaching process. In West Africa, a study in Ghana by Arthar-Baidoo et al (2022) and Trucano (2005) revealed that ICT use has seen tremendous growth in their uses in schools for teaching purposes. Their study posits that Maintaining ICT teaching resources help to put them at optimal condition for use by teachers and it encourages their integration in the teaching process. In support, a study in Nigeria by Olaniyan and Ojo (2018) shows that poorly maintained ICT resources is a major challenge facing successful integration of ICT in Nigerian senior secondary schools. Akinsanya (2020) further supports this by observing that in most schools in Nigeria, ICT resources are poorly maintained and principals do not value their maintenance hence influencing integration negatively.

Oni (2023) in a study done in Lagos state in Nigeria, indicated that integration of ICT in secondary schools has not been achieved. The study illustrated that; teachers' incompetency was a major hindrance to integration of ICT in schools. In terms of integration, Abubakar (2016) observed that, in public secondary schools in Nigeria more boarding schools had higher level of integration of ICT than day schools. In South Africa, a study by Musasa et al. (2025) in Guateng secondary school observes that there are several factors influencing

integration of ICT in teaching. The study states that the factors can be can be teacher related or school related. Teklesellassie et al. (2025). Did a study in challenges facing integration of ICT in Ethiopian teacher education colleges. The results showed that there were major barriers faced by the participants in integrating ICT in classrooms such as lack of technical support from the administrations of the colleges where they were teaching and limited access to the internet. Moreover, the results revealed that the participants believed that they had low competency which hindered them from applying ICT in their classrooms.

In East Africa, Habimana et al. (2025), did a study and reported that Rwandan lower secondary schools have the integration of ICT being influenced by inadequate digital competency, time constraints, and limited access to computer devices in school environment. The study also showed that teaching experience is a major factor that could have influence on integration of ICT in Rwandan senior secondary schools. Nyamwesa et al. (2022) did a study on the use of ICTs in Tanzanian secondary schools and discovered that teachers had poor integration of ICT in their teaching. The study noted that, this was due to poor teacher training in colleges and universities hence they were incompetent and lacked confidence to use ICT. Another study done by Nyakito (2021) supports the findings by showing that the factors influencing integration of ICT in secondary schools in Tanzania included; availability of ICT facilities, inadequate ICT teachers, poor internet connectivity, unsatisfactory teachers' remuneration and ICT incompetent teachers. In Uganda a study by Ezekiek et al. (2025), concludes that the integration of ICT in urban secondary schools in Uganda is faced with significant challenges, including inadequate ICT resources, limited internet access, and insufficient qualified ICT teacher. This has been supported by Abdi and Abdi (2025) in a study done in Mogadishu city secondary schools which concluded that while perceptions of use of ICT among teachers are positive, barriers like resource shortages and insufficient training hinder effective integration.

In Kenya, Chonge (2022) did a study in Webuye and observed that categorization of schools has an influence in utilization of resources since some schools get more funding and support while others receive poor funding. Nyangweso (2020) observes that the national, extra-County and County category schools are favoured while the Sub-County schools are disadvantaged in terms of resources and are poorly funded as per government capitation. Odhiambo (2019) confirmed that public boarding secondary schools are well established and have better integration of ICT than public day secondary schools in Kwanza Sub-County. Mutisya et al. (2017) conducted a study on use of ICT in and management of secondary schools in Kitui

County and reported that there are several factors that influence integration. In the study Mutisya noted that the factors could be related to school or to the teacher. The study concludes that availability of ICT resources, experience of the administrators and gender influences the integration. Muthoni (2017) did a study in Meru and Tharaka- Nithi Counties and noted that maintenance of ICT resources influences their integration in secondary schools.

A study in Mashuuru Sub-County in Kajiado County by Kerubo (2016) found that through supervision, effective curriculum delivery is enhanced, hence quality education is realized. In addition, the study noted that ICT integration principals' supervision enhanced integration of ICT. The findings are supported by a study done in Machakos County by Mulinge (2024) who noted that secondary school principals are the instructional supervisors in their schools. And further posits that supervision influence integration of ICT in secondary schools. From the studies cited, it's now evident that integration of ICT in teaching in secondary schools is influenced by several factors (Mutysia, 2017; Nyakito, 2021; Musasa, 2025). Studies have indicated that the factors influencing integration of ICT can be skewed towards the school or the teacher (Dirin et al, 2019; Akinsanya, 2020; Julianda et al., 2024; Pisa, 2025). In this regard, the researcher dichotomized the factors influencing integration of ICT into two. The two categories were personal and school level. The study therefore investigated the influence of personal and school level factors on integration of ICT in public secondary schools in Kiambu County, Kenya.

1.2 Statement of the Problem.

Despite ICT having found its use in all sectors of economy, its integration in teaching in secondary schools has remained an area of concern in Kenya with Kiambu County being no exception. Integration of ICT in teaching is influenced by several factors and the influence of these factors on integration of ICT in biology teaching is unclear and hence there is a need for information in order to address the issue (Mutisya et al. 2017; Nyakito, 2021; Musasa, 2025). This study therefore investigated the influence of personal and school level factors namely; gender, age, teacher competency, teaching experience, availability of resources, principals' supervision, principals' maintenance of ICT resources, school size and school category on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. How these factors and the extent to which they influence the integration of ICT in biology teaching in public secondary schools was the gap that the study filled.

1.3 Purpose of the Study.

The purpose of this study was to determine the extent to which personal and school level factors influence integration of Information Communication Technology (ICT) in biology teaching in public secondary schools in Kiambu County, Kenya.

1.4 Objectives of the Study.

This study was guided by the following eight objectives:

i) To determine whether teacher's gender has any influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

ii) To determine whether there is any difference in teacher's age on integration of ICT in biology teaching in secondary schools in Kiambu County, Kenya.

iii) To assess whether teacher's competence has any influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

iv) To determine whether there is any difference in teacher's teaching experience on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

v) To establish whether availability of ICT in school has any influence on integration of ICT in biology teaching of in secondary schools in Kiambu County, Kenya.

vi) To investigate whether there is any influence of principals' supervision and maintenance of ICT resources on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

vii) To investigate whether public secondary schools' size has any influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

viii) To determine whether there is any difference in public secondary schools' category on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

1.5 Research Hypotheses

The study was guided by the following null hypotheses tested at .05 level of significance.

HO_1: Gender of the teacher has no statistically significant influence on integration of ICT in biology teaching in public schools in Kiambu County, Kenya.

HO_2: Age of the teacher has no statistically significant difference on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

HO_3: Teacher's competency in use of ICT has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

HO_4: Teacher's teaching experience has no statistically significant difference on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

HO_5: Availability of ICT has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

HO_6: Principals' supervision has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

HO_7: Principals' maintenance of ICT resources has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

$H0_8$: Public secondary schools' size has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

$H0_9$: Category of the public secondary school has no statistically significant difference on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

1.6 Significance of the Study.

The findings of this study may be useful to a number of education stakeholders, especially at the secondary school level in the following ways.

i. Parents Association (PA) may use the findings of the study in soliciting funds to equip and maintain schools with ICT infrastructure.
ii. Board of Management (BOM) may use the findings to draw future plans for inducting teachers, procuring ICT equipment, building computer laboratories, raising funds for ICT equipment and other management decisions.
iii. Kenya Secondary Schools Heads Association (KESSHA) may use the findings to enrich teachers of biology seminars on integration of ICT in schools.
iv. The Kenya Institute of Curriculum Development (KICD), in the course of developing e-content for biology and various other subjects taught in secondary schools, will be able to enumerate the challenges facing teachers in the integration of ICT. KICD can

use the findings to facilitate further improvement of teachers training curriculum to equip teachers with knowledge on integration of ICT in biology teaching.

v. Kenya Education Management Institute (KEMI) may use the findings of the study to identify areas which need to be addressed during in-service training course for teachers of biology.

vi. The research findings may also serve as foundational information for the educational research community to proceed with further research on ICT integration and its impact on achievement and proficiency in delivery of the content in various other subjects.

vii. The findings of this study may provide insights on integration of ICT in teaching to the universities and teachers training colleges which are critical for the pre-service training and in-service training of secondary school teachers.

viii. The findings of the current study may provide the Ministry of Education (M.o.E) with data on which to base their decisions in training and support strategies in teaching in secondary schools. Information gained may be used reviewing policies for implementation of ICT integration in teaching in secondary schools. The ministry may also use the findings in sensitizing teachers of biology teachers by use of circulars on the potential of ICT as a tool for enhancing and improving biology teaching.

ix. Commission for University Education (CUE) in one of its main roles of setting standards relevant to university education, may use the findings to facilitate further improvement of teachers training curriculum to equip teachers with ICT knowledge.

1.7 Scope of the Study.

The study delimited itself to an investigation of influence of personal and school level factors on integration of ICT in biology teaching in public secondary schools in Kiambu County. These factors were; gender, age, teacher competency, teaching experience, availability of resources, principals' supervision, principals' maintenance of ICT resources, school size and school category. There were many other factors like teacher innovation, government regulations, availability of technical support, security and community support but they were not within the scope of this study. Kiambu County was selected due to the fact that no similar recorded study had been done before and therefore the county was considered as a rich area in terms of data.

1.8 Limitations of the Study.

According to Dubey and Kothari (2022) a limitation is an aspect of the study that the researcher knows may adversely affect the results or generalization of the study, but over which he/she has no direct control. The purpose of putting the limitations in the study is to help the reader recognize the problems, issues, and occurrences that may have arose during the study and were beyond the control of the researcher.

The study faced the following limitations.

i. Inability to control the respondents' unwillingness to respond to some research questions such as their competency. To avoid invalidation of the findings, the researcher assured the respondents of their confidentiality and encouraged them to participate in the study by showing them the importance of study and their contributions. In addition, the researcher assured them that the data given was only to be used for the purpose of the study only. Finally, the researcher provided a consent form to the respondents.
ii. Dishonesty. Some respondents may have been tempted to be dishonest as they answered questions. This was mitigated by the researcher briefing them before administering of the questionnaires so that they could understand the purpose of the study. A rapport was also formed to minimize dishonest responses for fear of victimization and therefore the study was not compromised.
iii. The study was limited to the public secondary schools only. The study was also limited to biology teaching in public schools and therefore the generalization of the findings may be limited to the subject and not others in public secondary schools.

1.9 Assumptions of the Study.

This study was carried out with the following assumptions in mind;

i. The study relied on self-reported data. The assumption was that the respondents were to provide honest and reliable information on the influence of personal and school level factors on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

ii. The study used teachers of biology handling form three class. The assumption was that teachers were using ICT and had taught their student long enough to understand both the syllabus clearly and integration process.

iii. The study assumed that teachers in the sampled public secondary schools had received pedagogical and content training and therefore were able to deliver the required content effectively.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents the reviewed literature on the influence of personal and school level factors on integration of ICT in biology teaching in public secondary schools. The literature has been reviewed under the following thematic areas; integration of ICT in the teaching process; teacher's gender and its influence on integration of ICT , teacher's age and its difference on integration of ICT, teacher's competency in use of ICT and its influence on integration, teacher's teaching experience and its difference on integration of ICT, availability of ICT and its influence on integration, principal's supervision and its influence on integration, principal's maintenance of ICT and its influence on integration, school size and its influence on integration of ICT in teaching and public secondary school categories and their difference on integration of ICT. The chapter has also presented three theoretical frameworks and a conceptual framework.

2.2 Integration of ICT in the Teaching Process

According to Alloqulov et al. (2022) and ITU (2007), the United Nations Education, Scientific and Cultural Organization (UNESCO) defined Information and communication technology (ICT) as forms of technology used for creating, displaying, storing, manipulating, and exchanging information. In general, ICT comprise of computers hardware and software, networks, learning management systems, e-mail, internet, telephone, television and radio. According to UNESCO (2002) and UNESCO (2007), the development of ICT has a long history and was necessitated by communication needs. Different studies by World Bank 2012; Microsoft (2006); Draxler (2002); Akinade e al. (2020) and Elwood and Savenye (2015) noted that people have devised various techniques for communicating their thoughts, emotions, needs and desires to others hence creating an identity of such a generation.

Several studies by Apsorn et al. (2019), Okumbe (2013), Atieno (2019), Gichimu (2016) and Adeyeye and Dasoo (2023) have indicated that global investment in ICT has led to improved teaching and learning in schools and has been initiated by many governments in the world. This was supported by Nut (2015) by illustrating that in United Kingdom, the government spent £3.5bn on educational ICT in 2015–16. While in United States, the expenditure on higher education institutions was $5.7 billion in 2016. In New Zealand, the government spends over $ 410 million every year on schools ICT infrastructure. Currently around the world, there is

growing consensus among education leaders, researchers and educators that teaching must change to help students learn and develop the skills they will need to succeed in the 21st century (Fredricks- Lowman &Smith- Isabell, 2021). A study done in East Asia indicated that the integration of ICT in education has the potential to promote educational transformation by motivating learning and leveraging efficiencies in education systems and practices (Trucano, 2016). This is supported by a report by UNESCO (2002) which states that ICT holds promise in providing not only anywhere and anytime access to knowledge, but also equal opportunities for networking and communication that allows knowledge sharing, participation, and lifelong learning.

According to the Government of Kenya (2021), Kenya has a National ICT Policy whose focus is the nation's aims, principles and strategies for the delivery of Information and Communication Technology to improve the livelihoods of over 40 million Kenyans. Gacicio et al. (2021) observed that Ministry of Education (MoE) introduced the National ICT Strategy for Education and Training in order to give an opportunity for establishment of grassroots-based infrastructure for knowledge sharing. The sessional paper 1 of 2019 on policy framework for reforming education and training for sustainable development in Kenya by MoE (2019) presents the ways in which information and communication technology (ICT) can be leveraged to support and improve the delivery of quality education and training for all Kenyans. It provides a comprehensive range of potential technologies to improve teaching, learning, and management. It is intended to enable the Government of Kenya (GoK) plan appropriate ICT in education interventions as they move forward with the comprehensive Kenya Education Sector Support Programme (KESSP, 2005). This includes interactive radio instructions (IRI), use of computers in schools, development of ICT skills and the access of internet. The Government of Kenya (GoK) and the United States Agency for International Development (USAID) have a joint commitment to improve education in Kenya in collaboration with Kenya's Ministry of Education. This is aimed at accelerating 21st Century Education (ACE) by improving the quality of primary and secondary education through the effective use of information and communication technology (ICT).

The initiative aims at establishing a school of Technology and Innovation Center (STIC) in Nairobi which will serve as a hub where education leaders and teachers access the latest information on technology solutions that are proven to enhance innovative teaching and learning, thus improving the skills needed by students to thrive in the 21st century (David et al.,

2019). Kenya has a government ICT Board whose main objective is to avail quality and affordable technical support to the Digital Villages to enable their smooth operation (David et al., 2019). The board has technical support focus points of standardized method for the testing and implementation of new software, the upgrading of hardware and the overall tracking of licenses and equipment. It develops a collaborative relationship with those responsible for technical support and encourages them to include capacity building in the planning of future changes. The board works closely with educational institutions to ensure quality technical services as well as the internet providers (MoE, 2021, GOK 2021). Farrel (2021) and Gacicio et al. (2021) in different studies noted that, the attempt to integrate ICT in Kenyan secondary schools faces various challenges such as lack of adequate number of computers in the schools, inability to acquire sufficient computers or update those which are obsolete due to lack of finances, fast changing technology and high overhead costs. In addition, loaded curriculum which makes it difficult to find time to prepare ICT teaching materials, resistance by teachers to use ICT and inadequate government employed teachers also impend integration. This is backed by the government report on ICT capabilities in secondary schools in Kenya which indicates that teachers lack innovation and willingness in use of ICT in the course of their teaching in secondary schools (MoE, 2019).

In Kenya, the Ministry of Education (MoE) basic education Act, defines ICT integration as "seamless incorporation of information Communication Technology to support and enhance the attainment of curriculum objectives, to enhance the appropriate competencies including skills, knowledge and attitudes" (MoE, 2015). According to MoE (2021) integration of ICT in education is so important that the Africa Agenda, 2063 and the Continental Education Strategy for Africa (CESA), 2016- 2025 emphasizes the use of ICT as an important tool in the achievement of quality education in Africa. In fact, the CESA strategic objective three emphasizes harnessing the capacity of ICT to improve access, quality and management of education and training systems. The Kenyan government has emphasized that integration involves using ICT in all stages of teaching (PWPER, 2023). This means a teacher can use ICT in lesson preparation, delivery of the content and assessment of learners. Wang and Woo (2019) postulated that depending on the scope of the content covered, ICT integration can happen in three (3) areas: curriculum (macro), topic (meso) and lesson (micro). They further elaborated that macro- integration entails use of multimedia resources and web-based courses. Meso involves smaller pockets of knowledge such as explaining the concept of Deoxyribonucleic acid (DNA) and cell division which are closely interrelated.

Lastly, micro integration entails use of ICT to explain specific knowledge units such as Ribonucleic Acid (RNA) in a cell. This is depicted in Table 2.1.

Table 2.1

Areas of ICT Integration

Area	How ICT is integrated
Macro	Exploit ICT to support complete content and learning experience of a whole content
Meso	Use ICT in certain topics to supplement students learning
Micro	Apply ICT in one or more lessons to help students understand certain concepts

Source: Adapted from Wang and Woo (2007)

The use of ICT in teaching has also been elaborated and placed in various categories. The three main categories are; learning resource, for instructional organization and for communication purposes. The use of ICT in teaching can be summarized as represented in Table 2.2.

Table 2.2

Manner of ICT use in the teaching process

Number	Categories	Application of ICT
1	Learning resources	- Educational software - Distributed resources - Video resources
2	Instructional organization	- Software and technological tools supporting face to face lessons - Course management system - Computer based testing
3	Communication	- Email system - Websites offering communication options for direct sending of emails and forms of structured communication - Software system for text-based chat - Use of social media such as whatsapp, twitter, Facebook, Telegram.

Source: Adapted from Collis and Moonen (2001)

Table 2.2 presents information on how ICT is used in the teaching process and its significance as a learning resource. It can be used together with other resources such as charts or on its own. One such use is when a teacher presents a short video clip in a form three class to show the process of cell division. In addition, other educational software and distributed resources via the internet are utilized. ICT is also used for instructional organization. This involves its use by the biology teacher to improve content delivery in classroom, as well as course management such as use of admission program for form one, discipline monitoring and CCTV camera programs and examination management. Examples of biology education software are biology Pro and Crocodile Biology. Finally, ICT is used for communication purposes. This mainly involves sending and receiving information by teacher online such as emails and on air such as short text messages and social media. Table 2.2 gives the extent to which ICT can be used by a teacher. ICT integration is something that must be done to improve teaching process in Kenya.

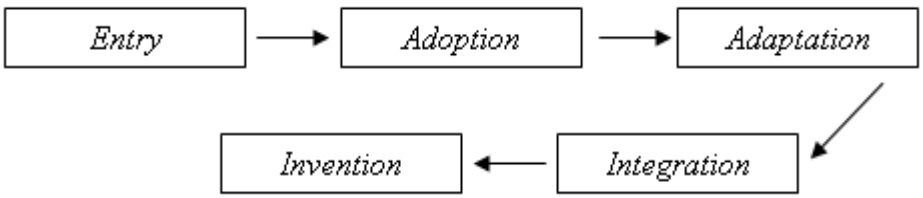
According to Mahdi and Dera (2014), integration of ICT in teaching does not simply mean the purchase of computers rather it should fulfill many conditions, including the introduction of the technology and ensuring a user-friendly maintenance. Mahdi and Dera noted that there is the right way of integrating ICT in the teaching process. Smith et al. (2020) pointed out that ICT integration has three stages; acquisition, introduction and maintenance. The acquisition stage refers the purchase of hardware and the software to be used for teaching. Introduction stage is composed of three elements: deciding where and how to locate the hardware and software; a comprehensive description of the role that the technology will play in biology teaching; and the process of acquainting the stakeholders with the technology so that they can use it efficiently and effectively. Lastly, maintenance comprises of regular and periodic checkup of the computers and other ICT resources in order to detect any trouble and put them into order.

In addition**,** Hwang (2015) discussing integration in Korean schools observed that it occurs in five steps. First is nurturing the competence of the teachers by equipping them with different aspect of knowledge, second step is coordination and cooperation based on practices, third step is utilizing ICT in class to deliver content. Fourth step is to encourage the teachers to be innovative and fifth is to be open enough to allow one learn from past experiences and others. Hwang further suggests that secondary schools should follow such a guideline in order to succeed in integration of ICT. Discussing integration in Nigeria secondary schools Sulaiman et al. (2020) noted that, it happens in steps where the ICT is acquired, teacher is trained on the use, utilization /use and evaluation is done. In Kenya, Miima (2014) noted that schools do not have a definite process for integrating ICT. Contrary to this, Kenya's Ministry of Education (MoE) policy emphasizes that integration of ICT in teaching and learning prepares a student to realize his/her technological potential (MoE, 2019).

Akram et al. (2022) distinguished five stages of integration of ICT a follows: Entry stage where teacher becomes aware of how to use information and communication technology in teaching. Adoption where teacher use ICT as supplementary aids in the context of traditional teaching/learning methods. Adaptation where teacher use ICT for expansion/enrichment of the curriculum. Appropriation where ICT is integrated and used due to its exceptional and unique qualities. Invention where new areas are invented and the use of ICT is appropriate.

Figure 2.1

Five Stages of ICT Integration



Adapted from Arkorful et al. (2021)

As it can be seen in Figure 2.1, in stage one (Entry) teacher, gets acquainted with ICT and how it can be used to facilitate teaching. In stage two (Adoption) ICT is treated as a useful but limited phenomenon. Teacher uses ICT to expand his/her personal tasks, such as administration of tasks, organizing schedules etc. In this stage teacher gives students examples and encourages learner use of technology. In stage three (Adaptation) ICT is used in class work. Teacher uses ICT to add variety to the teaching content but does not change their teaching style. Teacher uses compact discs, Internet, electronic encyclopedia to obtain information more often than traditional teaching/learning means books. In this stage teacher does not change the teaching form and it remains teacher-centered.

In stage four (Appropriation) the teacher begins to perceive the opportunities provided by information and communication technology and starts creating tasks that are pre-eminent in their possibilities. Learners start guiding their own learning and use ICT for their learning outcomes to achieve their higher order thinking objectives. This stage is also called the integration stage and technology is perceived as a useful tool. In stage five (Invention) the teacher starts changing the class and teaching setting to improve the use of ICT during lessons. ICT is used to achieve basic and higher order thinking skills. Invention occurs when the teacher creates tasks and even changes class environment to take advantage of the opportunities provided by ICT. To successfully integrate ICT, a teacher has to change even their teaching style and their approach to teaching. Junaidi et al. (2022) concludes that despite the apparent benefits of using ICT in education many teachers are not aware of how to integrate ICT in their teaching endeavor. It is in this context that; this study intends to investigate the influence of the selected factors in integration of ICT in biology teaching in public secondary

schools in Kiambu County. Junaidi et al. and Kola (2019) observed that ICT is significant in modern times, which is versatile in all spheres of life forming part of the youths' culture. The studies note that ICT is used for entertainment, social communication, searching, transmitting and sharing knowledge. ICT also develops desired skills such as problem solving, which are expected to be mastered by learners. ICT therefore is of great significance in education.

Junaidi (2022) pointed to substantial evidence that ICT is an integral part of the global society and its value in schools is to help in knowledge creation, knowledge sharing, problem solving, communication, group and cooperative learning. Supporting this Kola (2019) stated that new technologies have the potential to promote and to transform teaching and learning processes in secondary schools. Kola further asserted that ICT provides effective teaching-learning atmosphere by providing opportunities for effective communication between teachers and learners. This is confirmed by Aydin and Gurol (2019*)* who found that with ICT, the primary school teachers in China were able to use a variety of pedagogical approaches which included trans-missive, dialogic and constructionist approaches to allow learners in their English class construct their own digital stories, engage in dialogue and exchange through the comments posted in discussion blogs. Junaidi focused on learners in United States and observed that those with different learning styles and special needs can be assisted to manage their learning and to master the subject matter at their own pace by using specialized computer programmes. Junaidi concluded that provision of such facilities significantly helps the slow learners to catch up with the average learners and high achievers in a class.

Bahia et al. (2020) stressed that ICT is indispensable in teaching and learning as it provides access to information and provide learning beyond the classroom. He added that learners should use new ICT to access knowledge in order to be powerful as knowledge is equated with power. Adeyemo (2020) carried a study in Nigeria secondary schools and observes that the use of the internet by teachers for example, can be a source of reference and a means of communication with peers and the experts in underdeveloped and developing countries. Adeyemo adds that ICT offer unprecedented opportunities to promote and enhance educational systems and reduce the sense of isolation thereby providing access to knowledge in ways that were unknown before.

A study done by Young et al (2016) showed that integration of ICT in education has received acceptance in European secondary schools since it enabled the learner to grasp and understand difficult concepts in sciences. Young et al showed that integration of cartoons, pictures and voice captures the learner attention and motivates them to continue learning. The study observed that learners acquire diverse content within a short time. In support, Junaidi et al. (2022) concluded that integration of ICT contributes to development and promotion of a reading culture among secondary school students which is lacking in many schools. Aktaruzamzaman et al. (2021), Bahia et al. (2020) and Ayega (2020) agreed that it is imperative that teachers employ ICT to be able to teach 21st century learners and acquire new ways of teaching and learning which are considered to be relevant in the modern era that is powered by the use of new technologies. A study by Musyoki (2021) observed that if integration of ICT is done well by teachers, it could increase the learning activities and improve performance in general in Kenyan secondary schools.

On the other hand, research has shown that ICT use has some demerits. O'mara et al. (2017) did a study in Australia and realized that integrating ICT in teaching comes with some disadvantages. The demerits cited include too much time in delivery of the content that leaves no time to the students for the practice. The students therefore do not gain experience with the skills being taught. For the teachers they noted that they may not have adequate support and hence lose confidence in the use of the computer and its accompanying software. Sweeny (2020), Farrell (2021) and Mukuni (2019) concurred by adding that learners may not take their work seriously and may not apply what they have learnt. Atman-Uslu and Usluel (2019) did a study on using computers to teach reading skills in Australia and reported that reading skills developed from scrolling computer led to an accelerated but superficial and often inaccurate understanding of the content. From those studies, it is evident that integration of ICT poses a few disadvantages. However, Miima (2014) stated that many advantages supersede the disadvantages. The use of ICT is therefore considered an advantageous venture in biology teaching (Mutisya, 2020; Hadda & Jurith ,2000).

2.2.1 Use of Mobile Phones in Teaching

According to Bond and Bedenlier (2020), Use of mobile phones in teaching in a relatively new area in teaching. Jogezai et al. (2021) described use of mobile phones for teaching as electronic teaching through mobile computational devices such as mobile phones. According to Utulu and Alonge (2021), Mobile phones fall under a category of electronic devices called personal

digital assistants (PDAs). Ferry and Romar (2020) noted that mobile phones are good for teaching since are cheap compared to other devices hence more affordable, teachers and learners are able to identify with them at home and they have many other uses. He also notes that mobile phones can help users to access web-based content, remix it, share it, collaborate with others and create media deliverable to class and globe. Fang et al. (2020) did a study in China and found that majority of students used mobile phones to view their teacher's webpage, access online materials and take online tests. Ferry and Romar (2020), did a study in United Kingdom and found that lecturers communicate with one student or a group of students, send information about time table, send pop quizzes to students and remind students about dates of exams.

Use of mobile phones for teaching seems to have been left for higher education and not in use for teaching secondary and primary schools. For instance, UNESCO (2002) had shown that mobile phone learning projects have been used to improve learning systems in higher education. Utulu and Alonge (2021) did a study in Nigeria and revealed that mobile phones were used by lecturers to communicate with students on issues of the course, sending and receiving emails from the students, accessing public access catalogue and sharing knowledge through social networks such as YouTube, Skype, Wikis, Twitter, Whatsapp, Instagram, Telegram and Facebook, this is another evidence of the mobile use in higher education. The current study will address the use of mobile phones in teaching it's a very new area especially in teaching in secondary schools.

2.3 Gender of the Teacher and Integration of ICT in Biology Teaching

According to Ngo and Ngadiman (2021), gender differences and the use of ICT has been reported in several studies. However, studies concerning teachers' gender and ICT use have cited female teachers' low levels of computer use due to their limited technology access, skill, and interest (Hardaker, 2017; Karimi 2012; Susan & Rabillas 2022; Issa, 2021). A study in secondary schools in Meru by Koome (2017) reported that females' self-perceptions about technology competency was higher while males' self-perceptions about technological dominance was low. Koome was therefore in agreement with Chege (2014) that female teachers applied ICT more than the male teachers in secondary schools. The study by Koome was also confirmed report in a study by Ngo and Ngadiman (2021) that gender gap had reduced over the past years, presently, a greater number of females are using internet and web technology more than their male counterparts. Studies by Yuberta and Firmanti (2024) and Teklesellassie et al. (2025) revealed that female teachers outperformed male teachers in a

variety of ICT instructional uses and their scores in teaching using computers were higher than men. In support, studies among college instructors showed that female instructors used ICT more often than their male colleagues (Mercader & Duran-Bellonch, 2021; Zhang et al. 2020), although male teachers showed higher self-reported ICT skills and confidence in instructional use.

Danko et al. (2020), observed that certain studies conclude that gender differences in ICT integration in higher education do not exist. For example, while exploring how academic staff perceive the use of ICT at a university in Saudi Arabia, Alkhasawneh and Alanazy (2015) find no significant gender-based differences among the staff. They believe that this is due to ICT use having become normalised in today's world. This is in line with the findings of a survey in India by Bhat and Bashir (2017) that reveals no significant differences between male and female university teachers with respect to gender, and that males and females have a similar attitude to ICT use. Similarly, Soydal et al. (2012), analysed academic staff at a Turkish university and reveal that gender is mostly not a factor in e-learning readiness and whole integration process.

Edeh, et al. (2022), discovered that female college professors are significantly better at information and data literacy than male professors, who were on the other hand significantly better at communication and collaboration, digital content creation, and problem-solving. Findings by Tena et al. (2016) reveals that female instructors at college level use ICT more often than their male colleagues. The findings agree with the Teklesellassie et al. (2025) and Usman et al. (2021). Another study by Peng et al. (2023) examined how gender, age, and teaching experience influence ICT integration in elementary and secondary schools in Henan Province, of China. The findings of the study that involved 685 in-service teachers revealed that females exhibit higher levels of positive attitudes and digital competence than males. The study therefore concludes that female teachers integrated ICT more than their male counterparts in teaching. Some research studies have revealed that male teachers used more ICT in their teaching than their female counterparts (Seibert et al., 2019; Tay et al. 2012; Suraweera et al., 2017). Similarly, Khan and Markauskaite (2017), investigated gender differences in self-reported ICT experience and ICT literacy among first year graduate trainee teachers. The study revealed significant differences between males and females in technical ICT capabilities, situational and longitudinal sustainability where males' scores were higher.

Martin and Jamieson-Proctor (2022) conducted a study on teachers' integration of ICT in schools in Queensland State, Australia. Results from 929 teachers indicated that female teachers were integrating technology into their teaching less than the male teachers. Previously. scholars indicated that male teachers had more positive attitudes toward using ICT and other technological tools, used ICT more actively, had higher ICT self-efficacy and thus performed better than their female counterparts considering women have less time to interact using ICT, which leads to women to feel anxious, have a negative attitude toward the use of ICT, and incompetence (Li, 2025, Seibet et al.,2019; Udu & Oguegbulu , 2016; Ubugu, 2020). Danko et al. (2020) reported that male teachers stood at an advantaged point in terms of technology and therefore utilized technology more frequently and competently as compared to female teachers at the same level of education. A score of studies such as one done by Chapidech and Sriwasdi (2021) have revealed that gender variable is not a predictor of ICT integration into teaching since it has no significant influence on integration. A research conducted by Seibert et al. (2019), revealed that male teachers had relatively higher levels of computer attitude and ability before computer implementation, but there was no difference between males and females regarding computer attitude and ability after the implementation of the technology. Seibert et al. concludes that quality preparation on technology can help lessen gender inequalities.

According to Yuberta and Firmanti (2024), male teachers had more proficiency in using or operating digital tools in teaching mathematics in Indonesian schools when compared with their female counterparts. However, the study also noted that female teachers had better strategies to teaching and integration of technology in mathematics than male teachers in secondary schools level and hence no gender did better than the other one. According to Gebhardt et al. (2019) there are differences in the findings by various scholars which invite neutral outcomes for gender differences toward technology. Danko et al. (2020), in a study on gender influence noted that women have the same ICT ability as men, in whom they have high values in computer learning, letting them be role models for their use in teaching. Danko et al. concludes that gender cannot be used to predict the integration of ICT in teaching in secondary schools. This is also supported by Pang et al. (2022).

From the literature reviewed, the studies haven't reached a consensus on the exact influence of gender on integration of ICT in teaching. Therefore, to clarify those different findings, the current study sought to find out the influence of teachers gender and integration of ICT in biology teaching in public secondary schools of Kiambu County.

2.4 Age of the Teacher and the Integration of ICT in Biology teaching

Semerci and Aydin (2018) and Taylor (2019) noted that fewer studies are available on how teachers age is related to ICT integration in teaching in secondary schools and the few which are available do not completely agree on whether there is any significant difference in age. In support of this, Keržič et al. (2021), in research study reported that the relationship between age and teachers' adoption of ICT is inconclusive. The study noted that when looking at use of ICT in secondary education, one can see that some point to age differences while others do not at all.

Venkatesh (2022), addressed age and gender differences in the overlooked context of individual adoption and sustained usage of technology in the workplace. They studied user reactions and technology usage behavior over a 5- month period among 355 workers being introduced to a new software technology application. The results indicated that the decisions of men and younger workers were more strongly influenced by their attitude toward using the new technology. In contrast, women and older workers were more strongly influenced by subjective norm and perceived behavioral control. These groups of people adopt very different decision processes in evaluating new technologies.

Roberts et al. (2018) discovered that the probability that teachers would use ICT in the classroom was limited by the reality that teachers who were educated 20 years ago were trained by people who themselves were trained before the arrival of computers in schools and hence age is a factor that affect integration of ICT. In addition, Charles et al. (2021), carried out a study about technology integration in the schools. They used a qualitative study to examine the classroom practice of 30 "tech-savvy" teachers who used computer technology in their instruction. They found that young teachers, who were highly educated and skilled with technology, were innovative and adept at overcoming obstacles, but that they did not integrate technology on a consistent basis as both a teaching and learning tool. They stated two main reasons regarding these findings. First, students did not have enough time with computers and second teachers needed extra planning time for technology lessons. Other concerns were outdated hardware, lack of appropriate software, technical difficulties, and student skill levels. Šabić et al. (2022) conducted a study via an online questionnaire on a sample of 6613 elementary and upper secondary school teachers in Croatia. The findings indicated minor gender differences in self-efficacy for using ICT that are more prominent among older teachers and practically non-existent among younger teachers. These effects remained statistically

significant after controlling the type of school where the teacher works, perceived technical and professional support for using ICT in school, and frequency of use of computer programmes in teaching. The study concluded that younger teachers integrated ICT more that the older teachers.

In another study involving the influence of age on integration by Peng et al. (2023) which collected data through snowball sampling from 685 in-service teachers in Henan Province, China concluded that teachers aged 31–35 years had stronger digital abilities, digital tool use, and ICT integration compared to younger or older teachers. In his study of teaching staff in higher institutions in Egypt, Elsaadani (2013) found considerable age-related differences in attitudes to ICT. This has been supported by the world bank report (World bank, 2018). Similarly, a survey on university teachers in the Indian context by Bhat and Bashir (2018) reveals that age has a significant influence on teachers' view of the pedagogical usefulness of ICT. Younger respondents (aged up to 40 years) more strongly believed that ICT made their work easy and had improved their knowledge as opposed to their older colleagues. Another study conducted by Lin et al. (2014) shows similar results. The authors studied barriers to ICT adoption among university teachers of Chinese as foreign language from five US states. They found that younger teachers displayed more confidence in integrating ICT into their teaching. Similarly, Guillén-Gámez and Mayorga-Fernández (2020) in their analysis of Spanish higher education teachers found that age was an influential variable and a predictor of the overall attitude towards ICT use.

According to Mutisya (2014), the non-use of ICT by the older generation of teachers is a major obstacle that impedes ICT integration in teaching and learning. It emerged during the interviews that older teachers believe that ICT are not meant for them; as a result, they are anxious and are afraid of using ICT for teaching. Some old teachers do not know how to reconcile ICT and the subject matter. Expressions such as teachers being technophobic were used to describe all teachers who do not integrate ICT in their lessons. Kuskaya and Kocak (2010) analyzed teachers from Turkish vocational and technical schools and found that the younger the teachers were, the more they used ICT. Similarly, Zyad (2016) whose study of Moroccan secondary school teachers also showed a correlation between attitude to ICT integration and age, revealing that younger teachers are more likely to use ICT in their teaching. Likewise, Krumsvik et al. (2016) in their study of upper secondary school teachers found that teachers who are 50 years of age or older had less digital competency as compared to younger teachers. Therefore, showing that there was age difference in integration of ICT among teachers

in upper secondary schools. Keržič et al. (2021), noted that some research studies have shown that there is no age difference in integration of ICT among teachers. In support of this, Ravy (2020), found that age was not a significant factor in relation to teachers' attitude towards ICT integration. This negates findings by Venkatesh (2022). However, in another study by Afshari et al. (2012) it was revealed that age correlated negatively with the teachers' attitude towards ICT in Jordan (r = -.13, p <.01). Mahdi and Al-Dera (2013) did not identify any significant differences between younger and older instructors teaching English as foreign language at a university in Saudi Arabia.

A study of university as well as primary and secondary school teachers also did not detect any age-based differences in ICT use (Suárez-Rodríguez et al., 2018). Keržič et al. (2021) did a study and reported that many researchers have explored use of ICT for instructions in university education and realized several factors that affect its application in teaching. The study used quantitative data from a survey of 401 teachers from the University of Ljubljana in Slovenia to reveal any differences in instructional ICT use in terms of age. The results show that age is not a factor in instructional ICT use, although some age-related differences appear in teachers' personal ICT uses. In support of this, Semerci and Aydin's (2018) did a study of Turkish secondary school teachers' use of ICT and did not detect any significant differences between teachers in terms of age. Despite the growing number of authors, empirical research on how age relates to ICT use, the results are rather inconclusive. Therefore, the current study investigated the age difference and integration of ICT in teaching in secondary schools with an intention to contribute to closing this data gap.

2.5 Teacher's Competency in use of ICT and Integration in Biology Teaching

Semerci and Aydin (2018), defines ICT competency as being able to handle a wide range of varying ICT applications for various purposes. Igbasi and Iloanya (2017), Berner et al. (2022), Kushnir et al. (2014) and Shah (2022) teachers' ICT competence is a major predictor of integrating ICT in teaching. Evidence suggests that majority of teachers who reported negative or neutral attitude towards the integration of ICT into teaching process lacked knowledge and skills that would allow them to make "informed decisions". In support of this, Hofer et al. (2021), established that teachers devoid of ICT skills and knowledge do not integrate ICT in teaching and learning. Thus, rendering integration and implementation are an uphill task since instructors with limited experience with ICT fear to try using them, as posited by Yang and Lam (2021) who reported that teachers with low competency shy away from integrating ICT in their teaching endavours. Hofer et al. concludes that Teacher's competency is a key predictor

in ICT integration in universities. Marcinkiewicz-Wilk and Jurczyk-Romanowska (2018) showed that computer competency correlated with computer use among university lecturers in the United States of America. They, therefore, concluded that competency greatly influenced teachers' preparedness on ICT integration. Further, Shah (2022) established that ICT competency was fundamental to ICT integration in teaching and learning. Therefore, ICT competency has an influence on ICT implementation in schools.

Bariu et al. (2022) did a study on influence of teachers' competencies on ICT implementation in Kenyan universities. The study used 475 lecturers where the descriptive statistics results indicated a mean of 4.279 and a Spearman correlation of 0.618 between lecturers' competencies and use of software tools, implying that lecturers' level of competencies increases as they use and employ software tools when teaching. The chi-square test statistic indicated results of 288.498 and a significance of $P < 0.005$. The P value was less than the chosen significance level $\alpha = 0.05$, which checks for independence on the teachers' competencies on ICT implementation. The conclusion of the study was that there is significant evidence that teachers' competencies significantly influence ICT implementation. Though this is a case of the university, it can still give guidance on the influence of competency in integration of ICT in secondary schools.

Furthermore, it is also backed by other studies that used secondary schools' data such as one done by Michael et al. (2016) in Machakos County which used a sample of twenty-one (21) secondary school head teachers and one hundred and twenty-six (126) teachers. The study used questionnaires to collect data and after the analysis, it was established that majority of the head teachers and teachers had basic ICT literacy. However, only a few head teachers and teachers integrated ICT in teaching and learning due to their limited competency in ICT skills. The study concluded that there exists a significant relationship between teacher competency and ICT integration. This report also concurs with findings by Namaulula et al. (2023) and Mogeni et al. (2020). According to Munyemana et al. (2022), the success of educational innovations depended largely on the skills and knowledge of teachers. His findings point to the fact that teachers' lack of knowledge and skills was the second most inhibiting obstacle to the use of computers in schools. Similarly, in the United States Atman-Uslu and Usluel (2019), hypothesized that high levels of competency would produce higher levels of technology integration that will reflect on student achievements positively. Their model postulated that educators with higher levels of skill, knowledge, and tools would exhibit higher levels of technology integration in the classroom and vice versa. Moreover, Berner et al. (2022), studied

the relationship between computer use in the classroom and teachers' competency. The study found that the faculty's belief in their computer competence was the greatest predictor of their use of computers in the classroom. Therefore, teachers should develop their competence based on the educational goals they want to accomplish with the help of ICT.

According to Hirschbuhl and Faseyitan (2014) the technical orientation of the teacher was a significant predictor of integration. In contrarily some studies have reported no significant difference between teachers who integrated ICT and those that didn't in their personal attributes of competency (Abedi et al., 2023; Palagolla & Wickrama, 2022; Baubeng, 2021; Edward 2015) In support of this Shengru et al. (2018) in Malaysia posited that competency and gender are not a major determinant of teacher's integration of ICT in teaching process. According to Marina et al. (2023) many teachers without skills and knowledge were not enthusiastic about integration of ICT in their teaching activities. This makes it difficult for them to adopt it. Teachers with no experience with computers do not want to try and work with them because they could look like idiots and more stressed. Such teachers avoid completely integrating ICT into their teaching and learning activities (Lam, 2019). Studies done by Arvanitaki and Zaranis (2020) in Silicon Valley in America indicated that less than 10% of the teachers use computers in their classroom and many shy off due to lack of skills.

Lack of ICT skills and knowledge by teachers definitely affect their competency in integrating it in their teaching activities. The empirical literature has established a considerable research gap despite teachers' competencies being critical in ICT implementation. With this information in mind, the current study investigated the influence of teacher's competency on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

2.6 Teaching Experience and Integration of ICT in Biology teaching

According to Jibia and Ahmad (2021), Mou (2016), Bozkurt et al. (2020), Elwood and Savenye (2015) teaching experience could influence the adoption of an innovation such as ICT. The report by the US National Center for Education Statistics (2019) indicated that teachers with fewer years of experience were more likely to use computers in their classes than teachers with more years of experience. More specifically, teachers with three years or less teaching experience reported using computers 48% of the time; teachers with 4-9 years, 45% of the time; those with 10-19 years, 47% of the time, while teachers with 20 years or more reportedly used computers only 33% of the time. This may be due, in part, to the fact that new teachers have

been exposed to computers during their training and therefore, have more experience using this tool. Usman et al. (2021) posited that teacher experience is significantly correlated with the actual use of technology. The study further revealed that effective use of computer was related to technological comfort levels and the liberty to shape instruction to teacher-perceived student needs. Abedi et al. (2023), also claimed that experienced teachers are less ready to integrate ICT into their teaching.

Semerci and Aydin (2018) conducted a study on the extent of ICT adoption among 250 secondary school teachers in Malaysia. Their findings revealed that older teachers frequently used computer technology in the classrooms more than the younger teachers. The major reason could be that the older teachers have a rich experience in teaching; have better classroom management as well as competency in the use of computers thus can easily integrate ICT into their teaching. This concurs with Hinostroza et al. (2016) who found that new teachers who were highly skilled with technology more than older teachers who did not incorporate ICT in their teaching. The study cited two reasons: new teachers focus could be on how to use ICT instead of how to incorporate ICT in their teaching. Second, new teachers could experience some challenges in their first few years of teaching and spend most of their time in familiarizing themselves with school's curriculum and classroom management. In support on the fact that experience has an influence on integration, a survey involving 3000 teachers by Hinostroza et al. argued that the quality of ICT integration was related to the years of teacher service. Palagolla and Wickrama (2022), Edward (2015) and Aydin and Gurol (2019) observed that one of the factors that determine the extent to which teachers use computers in their classes maybe the number of years they have been teaching.

Zhao et al. (2021) did a study in Gansu Agricultural University, China and analyzed the impact of years of teaching experience on college teachers' digital competence. The study utilized a quantitative methodology and a sample of 536 in-service teachers completed a questionnaire on digital competence. The results show that the sample considered themselves positively in information and data literacy, communication and collaboration, security and problem solving, while they self-evaluated their digital content creation negatively. Regarding the variables studied, significant differences were found in favor of teachers with less teaching experience who thought themselves better in the areas of communication and collaboration, digital content creation, security and problem solving as compared with the older teachers. The study by Zhao et al. concluded that teaching experience has an influence on integration of ICT in teaching.

A few other studies have a different view on the influence of teaching experience on integration of ICT and have found no statistically significant influence. For instance, Joseph (2023) reported that teachers' experience in teaching did not influence the use of computer technology in teaching learners in secondary schools. A study by Li et al. (2021) in China has similar findings and concluded that teaching experience has not influence on use of computer technologies in teaching at all levels of education. In support of this, Palagolla and Wickrama (2022) conducted a qualitative survey on factors contributing to teachers' successful implementation of ICT in Canada. The findings found no relationship between teachers' teaching experience and influence the integration of ICT implying that teachers' ICT skills and successful implementation is complex and not a clear predictor of ICT integration.

From the prior available studies, the researchers don't agree on the effects of teaching experience on integration of ICT in biology teaching. This study in an attempt to fill in the gap therefore investigated whether there is a significant difference between teaching experience and integration of ICT in biology teaching in public secondary school in Kiambu County, Kenya.

2.7 Availability of ICT and Integration of ICT in Biology teaching

Bahia et al. (2020) did a study in Spain on use of ICT in society and postulated that the availability of a resource is the first step towards its use in teaching. In support of this notion, Li et al. (2018), observed that the availability of ICT in Malaysian secondary schools seriously limited what a teacher can do in the classroom with regards to integration. Far from Asia and Europe, Pang et al. (2022) did a study in United States and noted that teachers used computers for teaching since they were present in their places of work. In addition, Richardson notes that American secondary schools have successfully integrated ICT in teaching mostly due to the availability of the computers. In support Ravy (2020) did a study in Syrian secondary schools and observed that teachers comfortably integrated ICT in teaching since computers were at their disposal. In addition, the study noted that teachers also use computers for their own work outside the school. Ravy through his findings concluded that the main obstacle to technology integration in teaching worldwide is availability.

Looking at availability and funds Munyemana et al. (2022), Bhat and Bashir (2018) and Shengru (2018), stated that many scholars proposed that the lack of funds to obtain the

necessary hardware and software is one of the reasons why teachers do not use technology in their classes. Also, a report on teachers' use of technology by the National Center for Education Statistics in United States indicates a positive correlation between availability of computers and computer use (Trucano, 2016; Lawrence & Tar, 2018; Li & Wong, 2021). In another study on effects of availability of computers on integration in Saudi Arabia Universities, by Mahdi and Dera (2014), 78% of teachers surveyed cited limited access to computers as a major barrier to effectively integrating it computers in their classes. Of this, 38% thought inadequate computers were a great barrier to using technology in their classes. Therefore, efficient and effective use of technology by a large extent depends on the availability of hardware and software.

The situation is different in African countries where computers are insufficient. For instance, The African Union (2022) Digital Education Strategy and Implementation Plan states that the African Union (AU) recognizes that digitalization is a tool for addressing the challenges in the education sector and a driving force for innovation. The AU Agenda 2063 states that "well-educated and skilled citizens, underpinned by science, technology and innovation for a knowledge society. The plan notes that the integration of ICT in teaching is below average in all levels of education in African countries. In support of this, a study done in Nigeria by Karna (2021) showed that insufficient numbers of computers prevent teachers from using computers for teaching. This is because the computers are out of reach for the teachers. However, the study concluded that some African countries are trying hard to see that integration of ICT is achieved though they are still far. According to Fomunyam (2019), statistics on the efforts to use ICT in education indicated that Egypt with a total of 32,120 schools had 10,000 computers, Namibia with 1,520 schools had 60 and Ghana with 35,000 had 5000 computers. The study concluded that availability is a big challenge in Africa. In support of this Karna et al. (2022), noted that insufficient numbers of computers and other related ICT resources hinder teachers from using computers for teaching.

Obonyo (2019), Nyamweya and Otieno (2020) and McLeod (2020) noted that in Africa especially rural areas have many challenges such as electricity connection, network configuration, frequent power break downs and power cuts that increase cost of ICT infrastructure making rural areas almost impossible to access and integrate ICT in the teaching process. According to MoE (2021) availability of ICT resources is one of the major challenges facing their integration in education in Africa, Kenya being no exception. MoE denotes that

while the ratio of one computer to 15 students is the norm in most developed countries, the ratio in Africa stood at one computer to 150 students and it is even bigger in disadvantaged regions and areas. In Kenya, the ratio for universities and colleges was one computer to 45 students, Ministry of Education: Policy on Information and Communication Technology in Education and Training notes that there is one computer to 120 students at secondary school level while access at the primary school level remained much more limited at one computer to 250 students. (MoE 2019) According to the e-readiness survey conducted in 2016, secondary schools have a computer to student ratio of 1:92. In TVET, the student to computer ratio ranged from 1:4 to 1:50 (ICT Infrastructure Review Report, 2017). According to Miima (2014), Malusu (2012), Wachiuri (2015) and Karanja (2015) Kenyan schools were under equipped with ICT. The researcher further notes that this could be one of great hindrances to integration of ICT in secondary schools (Miima, 2014).

In conclusion, lack of ICT limit teachers uses and poses a huge barrier to its integration in schools (Kanyoi, 2019). It is true that teachers who have computers in their classes are more likely to use them for instruction than teachers who do not have them. The existing knowledge seem to be pointing to that fact that availability influences integration of ICT in teaching. However, there seems to be a gap and the current study intended to fill in. The researcher therefore investigated influence of availability of ICT on biology teaching in public secondary schools of Kiambu County, Kenya.

2.8 Principals' Supervision and Integration of ICT in Biology Teaching

Irvin et al. (2018) defined teacher supervision as a process of monitoring a person's ability to achieve organizational goals. The main task of supervision is to improve the teaching situation in a school (Supriyono et al. 2018; Zapenda, 2012; Muse 2017). Supervision is all assistance from school leaders, which is aimed at developing the leadership of teachers and other school personnel in achieving educational goals. It is in the form of encouragement, guidance, and opportunities for the growth of skills and abilities of teachers, such as guidance in implementation of reforms in education and teaching, selection of learning tools and teaching methods that are better, ways of systematic assessment of phases of the entire teaching process, and so on Gordon and Sayed (2020), argued that the main task of supervision is to improve the teaching situation. Kipngetich and Ahmed (2012) notes that the head of institution is the supervisor of the teaching activities in the school. According to Altun and Sarkaya (2020), the function of supervision in education is not just a control to see whether all activities have been

carried out in accordance with the plans or programs that have been outlined, but more than that supervision in education contains a broad meaning. Mugambi (2017) noted that supervision is a process of overseeing something being done.

In Kenya, the management of public secondary schools is by board of management (BOM) which came into place after independence following recommendation by the Kenya Education Commission report of Ominde (Mugambi, 2017). The principal is the secretary to the board of management and is expected to offer technical advice on the school management (Agonga & Muhingi, 2020). Mogeni (2020) noted that this aimed at giving each school its own personality and decentralization of authority for effectiveness. Education Act 2011 and sessional paper No. 1 of 2005 state that the board of management have been given the role of managing human and other resources so as to facilitate smooth operations, infrastructural development and provision of teaching and learning materials (MOE, 2019; Akala, 2021). According to Moyo (2022) a school principal has three sub-tasks to perform in teacher supervision in the school namely; instructional supervision, professional development and teacher evaluation. Instructional supervision is the act of overseeing a teacher carry out his/her roles as required (Musyoki, 2021).

Mugambi (2017) stated that instructional supervision is aimed at improving teaching for providing better education therefore supervisory activities can be considered as strategies employed by any institution to realize instructional competency. Mwangi (2014) added that instructional supervision is one of the key roles of the school principal. The school principals engage in a number of supervisory activities which include but not limited to the following: classroom visits, checking of teachers' professional records, direct lessons observation, organizing, and coordination of supervision activities (Ngunjiri, 2012). Obunga (2019) noted that meaningful learning may not take place in an environment with inadequate supervision while Kiptum (2018) supported this by noting that quality of education depends on the nature of leadership provided by the principal especially instructional supervision. According to Reche et al. (2022), principals as supervisors are responsible and expected to initiate activities that make learning process friendly to the learners such as use of technology in teaching.

Namunga (2017) Obunga (2019) indicated that supervision is aimed at improving teaching and the principal should be willing to carry out this process so as to motivate teachers and influence their use of technology in teaching. Malunda et al. (2016), added that principals are central agents of change and their level of supervision influences instructional activities such as use of

technology in teaching. Musyoki et al. (2021) stated that the principal's instructional supervision role include checking of teachers schemes of work, lesson plans, lesson notes, record of work covered, visiting classes, observing actual teaching, checking use of technology in teaching, checking on use of chemicals and apparatus, inducting the new teachers, checking progress records, checking attendance registers among others. Reche et al. (2021) added that the principal should not ignore checking the material that teachers use for delivery of the content to the learners. Namunga (2017) noted that there are three levels of instructional supervision practiced by the principal namely; direct, intermediate and general. Mugambi (2017), maintained that level of supervision of the principal determines how the teachers deliver content to the learners in terms of the materials use.

Obunga (2019) observed that level of the supervision determines whether technology is integrated or not. Mwangi (2014) supported this by indicating that classroom observation by principals enhance use of technology in teaching and apparently improves learners' performance in national examinations. Minga and Ghosh (2024). posits that its sole responsibility of the principal to supervise the use of technology in teaching and encourage its use. Aramide and Akinade (2016) noted that where principal use direct supervision of instructions, use of technology to teach is most likely across all the teaching subjects while Alimi et al. (2012) added that principals with general supervision don' t take keen note of the use of technology in teaching and therefore teachers don't use it. Donaldson and Jackman (2025) did a quantitative study on the impact of principals' supervision on ICT integration in Antiguan Secondary Schools from the perspectives of teachers and students. And the study concluded that there was a positive correlations related to higher levels of principal's involvement in supervision of teachers.

From the studies presented it has been noted that the level of supervision by the principals is a key influence to the integration of ICT in teaching. However, it doesn't seem clear how principals' supervision influences the integration of ICT in biology teaching in secondary schools. In fact, there are no known prior studies that have looked at influence of supervision on integration of ICT in teaching. Therefore, the researcher investigated the influence of principals' supervision on integration of ICT in biology teaching in public secondary schools of Kiambu County.

2.9 Principals' Maintenance of ICT Resources and Integration in Biology Teaching

According to Kagochi (2022), maintenance of ICT resources involves ensuring the proper functioning of resources within an educational setting. This includes both the physical upkeep of hardware and software to ensure efficiency and effectiveness. Effective maintenance and integration require a multi-faceted approach encompassing regular upkeep, user training, and a clear understanding of how technology can best support organizational goals. World Bank (2018) in a study on secondary education in Sub-Sahara Africa reveals that ICTs were not only inadequate but poorly maintained among rural and urban schools in the area of study. This was supported by Wang and Wood (2001) and Cohen et al. (2000). Similarly, Asiabaka (2018), did a study on effective management of schools in Nigeria and noted that the school heads have little concern on the state of resources and this has led to poor ICT resources in secondary schools. This is because while some have well equipped ICTs for effective teaching others have none and where they exist, such resources are poorly maintained. In the same vein, Olaniyan and Ojo (2018) also noted that lack of training manuals, poor maintenance of ICT resources and poor induction in use of ICTs are challenges facing successful integration of ICT in Nigerian secondary schools. They add that most teachers use trial and error method to connect laptop to the power and LCD project which may cause the equipment to develop mechanical challenge. This is supported by Sayo (2016) who notes that proper maintenance will help a lot in integration of ICT resources in teaching in secondary schools. Akinsanya (2020) observes that there is a general lax in principals when it comes to maintenance of resources. He concludes that most principals see it as a waste of money to maintain ICT resources while others say that it's an expensive exercise.

Igbinomwanhia et al. (2021) in a study done in Nigeria, noted that the principals' maintenance of resources is direct correlated with the level of integration of technology in schools. He observed that schools in Nigeria where the principal take responsibility of regularly checking on the function-ability of the ICT equipment in schools and repair or replace them, he/she together with the teachers are motivated to integrate them. In contrast he noted that, where the resources are poorly maintained or not repaired, teachers show laxity in integrating them to teach various subjects. Mogeni (2020) in his study on instructional management notes that, most principals have a negative attitude and say it's very expensive to maintain ICT resources for instance to replace the lens of LCD projector which costs about 27,000 Kenya shillings in the local market. Muthoni in support of this noted that most principals had issues when it came

to maintenance of ICT resources and do not want to get bothered in regular repairs of ICTs (Muthoni, 2017).

Kagochi (2022) did a study and observed that ICT teaching resources are poorly stored and lack good inventory. He concluded that poor storage led to destruction of ICT resources and eventually the principals are hesitant to repair them. Sayo (2016), Odhier et al. (2019), Umoh (2015) and Usman (2015) confirmed this by noting that the ICT equipment have no definite and agreeable storage space in majority of secondary schools which affects their function-ability and apparently maintenance. In addition, he observed that in some schools they are stored in the principals' office while others store them in the laboratory or secretaries' office and a few schools store them in deputy principals' office. Mwangi et al. (2023), argued that ICT resources that keep on being moved from one place to another for use are easily damaged such as in the course of being transferred and therefore their life span is greatly reduced. Sayo also noted that lack of a definite storage space affects maintenance and lead to loss of some items to thieves especially LCD projectors. Okoth (2018) did a study on principals' role in instructional management in schools and noted that it's the role of a principal to provide and maintain teaching resources including ICT materials. He added that a principal guides the BOM on various budgetary allocations of which the acquisition and maintenance of materials is a requirement. Mugambi (2017) insisted that a principal with good managerial skills would utilize money in budgetary allocation to repair and maintain resources in the school. Mwangi (2018) concludes that such money would be used for repair and maintenance of the ICT resources such as repair of LCD projector lenses and replacement of power supply equipment and cables.

Alamide and Akinade (2016) noted that most principals don't take keen interest in repair and maintenance of teaching materials and instead blame teachers for misuse and storage. They hence conclude that this attitude frustrates the teacher who is the end user of the ICT resources. Mutisya (2014) from her study to find out the factors influencing integration of ICT in management of schools in Kitui County, posited that low supervision level, poor storage, lack of proper inventory records and poorly maintained ICT equipment were some of the factors affecting integration of ICT in secondary schools in Kitui County. She added that most teachers were found to be demotivated to teach using ICT since the equipment were poorly maintained. Iqmaulia and Usman (2019) noted that central to the use of ICT resources is their maintenance. they added that ICT resources needed to be continually maintained since they use power and may develop a breakdown and furthermore, they have a lifespan of 5 years which most school

principals don't usually understand. According to Wyse et al. (2021), Usluel et al. (2008) and Chuktu (2021) in some instances principals failed to maintain supporting infrastructure for the use of ICTs such as internet. Akinsanya (2020) and Odeny (2022) commenting on maintenance of ICT resources posited that, schools with poor maintenance eventually don't achieve integration as intended. Obunga (2019), noted that despite the initial training received by principals on management of school, secondary schools still have serious dilapidation in resources including non-functional ICT resources. He added that this happens despite the fact that the government has allocated funds for free day secondary education.

Okoth (2018) and Manduku et al. (2012) posited that for teaching to be effective, the teaching resources have to be in good condition, well maintained, serviced and repaired. Okoth concluded that resources especially ICTs are of considerable investment of public funds and maintenance is essential to protect this investment. Yego (2021) in support noted that renovation and repair of non-functioning equipment should be done regularly to prolong the life span of an equipment. Kundu et al. (2022) in his study on competences needed by secondary school principals in Kakamega County concluded that maintenance of working condition and standards of audio-visual equipment is a key influencer to its use by the teachers. Msafiri et al. (2023) in their study on the integration of information and communication technology (ICT) tools in secondary schools analyzed the impact of ICT integration on the teaching and learning process based on 51 sampled studies. Their findings found that the main challenges affecting integration of ICT in secondary schools included professional development, pedagogical and technological knowledge, and resource maintenance. The study also noted that among the best practices and strategies to resolve these challenges were regular systems maintenance and engaging all stakeholders in ICT integration. The study further recommends that practitioners should adopt, adapt, involve diverse and dynamic ICT tools and methods in secondary schools and above all maintain ICT resources in good shape for use by the teachers.

Ministry of education in its report noted that maintenance of teaching ICT resources, good storage and maintenance of other instructional materials are very important in accomplishing the principle of sustainability as laid in the school resources procurement policy (MOEST, 2008; MoE, 2019). In support of this Muhuro and Kangethe (2021) and Kozma and Vota (2014) observes that in many public secondary schools the available teaching materials are not properly maintained and, in some cases, there is no specific period of replacement of spoilt and lost items by principal. They therefore conclude that maintenance of ICT resources helps the

teacher to integrate the ICT with ease. Kaaria (2009) in his study on availability and utilization of resources in teaching of English language in public primary schools established that most of the ICT teaching resources are poorly maintained and the head teachers are not concerned about them. He concluded that the head teachers should put effort to maintain ICT resources in their respective schools. Kagochi (2022) supports this by observing that there should also be regular auditing of resources to ensure they are not lost, damaged or destroyed which will motivate the teachers to utilize the ICT resources.

From the studies presented there is evidence that schools with well-maintained resources, teachers are motivated to utilize them for teaching purposes. However, from prior existing studies there seemed not to be a clear picture on how and the extent to which maintenance of ICT resources influences integration of ICT in teaching in public secondary schools. In addition, there is no available existing literature showing the situation in Kiambu County. The current study therefore looked at the influence of principal's maintenance of ICT resources and its influence on integration of ICT in biology teaching in public secondary schools of Kiambu County, Kenya.

2.10 Public Secondary School Size and Integration of ICT in Biology Teaching

Ornstein (1991) did a study in United States of America (US) on influence of school size on the school effectiveness. The study found that schools are either small or large depending on the population of students enrolled in the school at that particular time. This notion is also supported by Khalid et al. (2023) who states that in terms of size, secondary schools are either large or small. Solberge et al. (2022) postulated that a school should be considered small when there is underutilization of staff and the cost per student exceeds average cost in the state. On the other hand, they stated that a school can be considered large when personal or school identity among students is lost. This means that the students are unable to fully participate in co-curricular and extra-curricular activities or they have difficulty interacting among themselves or they feel they do not belong to student body or school in general. In support, Kennedy (2003) agreed with the school sizes and adds that a secondary school with less than 500 students should be considered a small school while one with more than 500 students is considered a large school. Other studies done elsewhere seemed to agree with the classification done (Kennedy, 2003). Solberg et al. (2022) in their study concluded that size of schools depending on the number of the students appeared to be largely acceptable among the researchers. This idea is also supported by Cotton (1996), Humlum and Smith (2014) and Luyten et al. (2014).

Perzigian and Braun (2020) observed that mainly the studies done on school size have looked at its influence on performance and very few studies have looked at otherwise. For instance, Luyten et al. (2014) did a study on school size and concluded that the size of a secondary school has influence on social equity and achievement to a lesser extent. Kennedy (2003) found that large school have good per pupil operational cost hence are cheaper to operate as compared to small schools. Stevens et al. (2021) noted that school size is an important policy parameter all over the world and the policy makers prefer large schools due to economies of scale associated with administrative costs. This is also supported by Perzigian and Braun (2020). In addition, they emphasized that large schools attract more qualified and experienced teachers. Hargreaves et al. (2023) concludes that historically, large schools have been advertised as providing better education than small schools. A study on school size in United States of America by Cotton (1996) reported that public secondary schools were allocated resources according to the number of students enrolled. The study further postulates that Districts schools in 14 states with many students received more funding and teachers by ratio of students to cater for large curriculum areas offered. In another study by Luyten et al. (2014) showed that large schools receive huge state funding and in additional receives funding from donors such as Michael and Susan Dell Foundation. In conclusion Luyten et.al. (2014) observed that large schools have advantages since they provide opportunities for cost saving through economies of scale, they get an extra funding from the state and offers a more diverse curriculum as compared to small schools. This is also supported by Sorberge et al. (2022) and Tay (2011) who showed that the trend is the same in most African secondary schools. Yang and Seyed Alitabar (2024) in a study done in Iran observed that school size significantly influences the educational environment, affecting everything done in a school. In addition, they noted that while smaller schools excel in creating a cohesive community, they often struggle with resource limitations and opportunity diversity. Larger schools, on the other hand, offer extensive resources and opportunities but may lack the close-knit community feel that enhances student engagement and sense of belonging. This study though not directly related with integration of ICT, it gives insights on how school size may influence teaching activities.

According to Koussihouèdé (2020), economics of education research has not reached consensus on the role of school size on the teaching and learning process in schools. The study observed that although many studies have looked at class size, none has investigated in any

depth the effect of school size on teaching process in Sub-Saharan African countries. A study by Koussihouèdé, (2015) has empirically shown that small schools foster better learning including use of resources. Other studies such as Wyse et al. (2008) find that school size has no effect on teaching/ learning process. Koussihouèdé in a comparative study between small schools and large schools and their influence on quality of teaching and learning in Senegal. This study concludes that the size of a school doesn't have an influence on quality of teaching and learning. This supports the fact that size of a school doesn't have an influence on ICT integration.

According to Kiumi (2008), Schools in Kenya at all levels have increased both in sizes and numbers since independence which has been occasioned by increase in population. Kiumi cited that in 1963, the enrolment of public secondary schools stood at 30,120 students and 882,000 in 2003 representing nearly 3,000% increase in four decades. Kiumi et al. (2013) added that in 2008 the enrolment stood at 1,382,211 which was 156.7 % increase in 5 years. Luyten (2014) observed that school size is a factor that affects teaching in secondary schools and can't be ignored. According to MoE (2021) and GOK (2022) the public secondary school student's population has continued to grow since inception of Free Day Secondary Education (FDSE). Further it was noted that the growth was by 8% from 3,260,000 in 2019 to 3,520,400 in 2020. Table 2.3 show the public secondary school students population in Kenya for the last six years.

Table 2.3

Public Secondary Schools Students' Enrolment in Kenya for the Last Six Years

YEAR	PUBLIC SECONDARY SCHOOLS STUDENTS' POPULATION
2015	2,559,000
2016	2,720,600
2017	2,830,000
2018	2,942,700
2019	3,260,000
2020	3,520,400

Source: MoE, Kenya Education statistics (2021)

Kiambu county public secondary schools hosts 89,065 students of which 44,777 are male while 44,288 are female. The County has both large schools and small schools. In Kiambu County, 73.19% of public secondary schools are Sub-County while 18.21% are County, 6.529% are Extra- County and 2.061% are National schools. Kiambu County hosts all categories of school with large proportion of the schools being small schools. The existing literature does not show how school size influences integration of ICT in Kiambu County secondary schools. The current study interrogated the influence of school size on the integration of ICT in biology teaching in public secondary schools of Kiambu County, Kenya in order to fill in the existing gap in knowledge.

2.11 Public Secondary Schools Category and Integration of ICT in Biology Teaching

Studies on school categorization are rare and the available ones investigates relationship between the school categorization and achievement such as one done by Eisenkopf et al. (2015) and Saidin and Brachim (2013). In their study Eisenkopf et al. concluded that Public secondary schools have categories all over the world. This is supported by Nyangweso (2020) in his comparative study on categorization of schools and notes that, various countries categorize their schools differently. For instance, in Germany there are four categories which are made according to academic performance of the learners from primary schools with the category of gifted children receiving a lot of attention and funding from the state. In France, High school (Lycee) has three categories namely general, technical and professional while in United States there are three categories of state secondary schools and England has eight categories. Similarly, Saidin and Brachim observes that Malysian secondary schools have four Categories while Ghana has four categories namely A, B, C and D. They conclude that Uganda and Tanzania have three and two categories respectively. There is therefore enough evidence showing that schools all over the world are categorized.

According MoE (2019), in Kenya categorization of public secondary schools is based on entry behaviour of the learners based on their Kenya Certificate of Primary Education (KCPE) and yields four categories namely; National, Extra-County, County and Sub-County. Nyangweso (2020) observes that majority of students who scored C+ and above in KCSE were from national, extra-County and county schools while 94% of those who scored D and E grades were from sub-County schools. The study concludes that Sub-County schools are small in size, lack experienced teachers, have inadequate resources and are poorly funded as per government capitation. On the other hand, the County, Extra- County and National schools receive huge funding as per student capitation, they have a well-established mechanism of income

generation, have well established alumni associations, attracts funding from Non-Government Organizations (NGO) and are a major beneficially of government projects. The three categories are therefore advantaged over the sub-county category.

The Kenyan educational budget allocation in financial year (FY) 2022/2023 stands at 544.4 billion shillings which is 23.9% of Gross Domestic Product (GDP) where 64.4 billion shillings went to Free Day Secondary Education (FDSE) while 310 million shillings were given to digital literacy program. The funding of education in Kenya is by capitation rate per student where each student enrolled in public secondary school receives 22,244 shillings each year for Free Day Secondary Education (FDSE). The enrollment data used is as in National Education Management Information System (NEMIS). National and Extra- County schools have enrollment of over one thousand students hence they receive the largest chuck of money for free day secondary education. In addition, they have good infrastructural facilities and have been in existence for a long period while sub-county and county schools receives the least funding since they are small schools in terms of enrollment.

Studies looking at the type of school (day or boarding) have shown a significant relationship between the type of school and integration of ICT. In such a study, Abubakar (2016) stated that, in public secondary schools in Nigeria more boarding schools have higher level of integration of ICT than day schools. In support of this, Wangili (2017), established that there is a difference in ICT integration between day and boarding public secondary schools in Trans Nzoia County in Kenya. Odhiambo (2019) confirmed that public boarding secondary schools are well established and have better integration of ICT than public day secondary schools in Kwanza Sub-County. In Kenya, National; Extra-County and County public secondary schools are mostly boarding therefore from the prior studies are most likely to have good facilities and resources. However, the current study looked at categories and not types of schools though related, are different. Tondeur et al. (2009) did a survey of 527 teachers in 68 primary schools in Flanders (Belgium) that focused on teacher perceptions about structural and cultural school characteristics and their use of ICT in the classroom. In order to study the variables at school level, teacher responses were aggregated. The next step was to delineate school profiles originating from structural and cultural school characteristics by using a cluster analysis. Finally, the relationship between these school profiles and ICT integration was studied. The results suggest that school category have no influence on integration of ICT but rather others cultural factors.

There is no existing and recoded literature on how the categorization of schools influences integration of ICT in teaching in Kiambu County public secondary school. The current study therefore, interrogated the relationship between the school category (whether the school is National, Extra- County, County or Sub-County) and integration of ICT in Biology teaching in public secondary schools in Kiambu County, Kenya.

2.12 Theoretical Framework

Three theories inform the study of integration of ICT in the teaching of biology. These are Technology Pedagogy Content Knowledge (TPACK) theory, constructivism theory and Diffusion of Innovation Theory (DOI). The TPACK theory addresses the relationship existing between pedagogy (teaching knowledge), knowledge of the content being taught and proficiency in technology and how they affect each other. The Constructivism theory on the other hand gives a fundamental understanding of dynamics of using technology in acquisition of new knowledge. It is the theory that justifies how new knowledge is acquired and built on existing one. The Diffusion of Innovation Theory explains the management of integration of ICT in a school situation. The use of the three theories is therefore important in understanding the integration of ICT in teaching. The theories are presented as follows.

2.12.1 The Technology Pedagogy Content Knowledge (TPACK) Theory

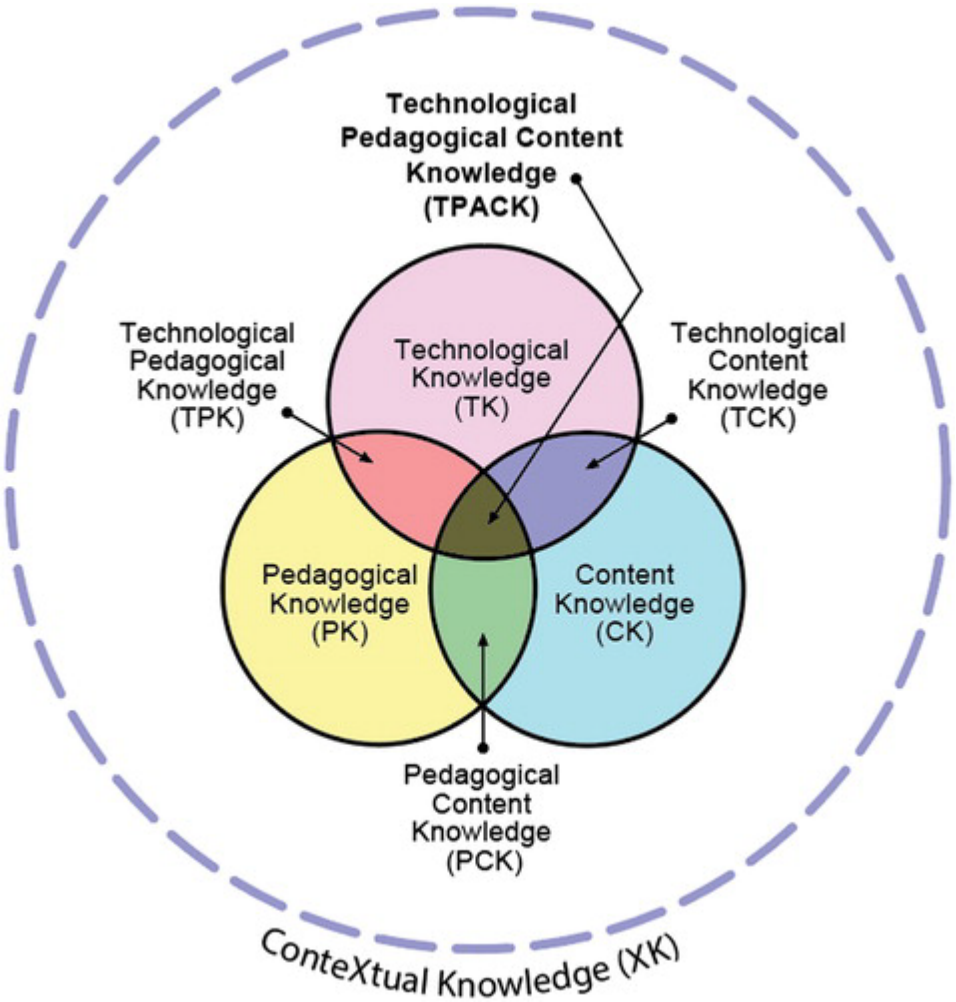
The proponent of this theory is Shulman (1986) who conceptualized the theory in form of a model which has Technology, Pedagogy and Content Knowledge (TPACK). This TPACK theory was further popularized by Mishra and Koehler (2006) and Rosenberg and Koehler (2015) who improved on it by showing the relationship between technology, pedagogy and content knowledge. According to Herring et al., (2016) the TPACK model describes the inter-relationship between content, pedagogy and technology, and emphasizes on integration of the three areas in developing effective teaching for learning. Knowledge of content (C) in the model is an understanding about subject matter. Teachers of biology must be knowledgeable in what they are teaching this include the facts, concepts, principles, theories, procedures and the structure of knowledge. Pedagogical knowledge (P) is knowledge about teaching and learning. Teachers of biology need to know how learning takes place; for example, how students construct knowledge and what a cognition process is, methods of teaching, student assessment, instructional design and classroom interactions. In the use of ICT in biology teaching in secondary: Technology and pedagogy management are also elements of pedagogical knowledge. Technology knowledge (T) involves the awareness of and skills in

operating and applying technology such as computer software, the internet and liquid crystal display (LCD) projectors.

Pedagogical content knowledge exists in the intersection of content and pedagogy and it is the knowledge about teaching specific subject matter (Mishra, 2019). It is concerned with the arrangement of content, the representation and formulation of the subject, the analogies and demonstration of ideas in easily comprehensible ways for learners. Technological content knowledge associates the application of technology in teaching subject matter of biology. An example of technological content knowledge is the understanding of statistical computer software (such as SPSS) and their applications into the subject matter statistics. Technological pedagogical knowledge, an overlapped area between the technology and pedagogy circles, refers to the ability of using technology in a way that supports the pedagogical approach. An understanding about existing technologies such as MS PowerPoint, digital cameras, animations and WebCT as well as the capabilities of utilizing them in teaching is illustrative of technological pedagogical knowledge (Rana et al., 2022). The Figure 2.2 that follows shows the interrelationship between various knowledge as depicted by TPACK theory.

Figure 2.2

Revised version of the TPACK model.



Source: Adopted from Mishra (2019).

Figure 2.2 is a Venn diagram. It's derived from mathematical concept of sets. As illustrated in the center of the model, technological pedagogical content knowledge, an emerged form of knowledge, is essential for successful application of ICT in teaching (Mishra, 2019) and is the focus of this study. It is the integration of teachers' understanding about the subject, knowledge about teaching and learning, and the ability of using technology. Thus, technological pedagogical content knowledge is the knowledge of how to teach the content of subject matter using technology in a way that facilitates learning. Each circle represents a type of knowledge.

According to Mishra (2019), the outer dotted circle "Contextual Knowledge" (i.e., the teacher's knowledge of the context) is everything from a teacher's awareness of available technologies, to the teacher's knowledge of the school, zone, sub-County, nation, or national policies of

education they operate within. The benefit to Contextual Knowledge is that it makes the outer circle another knowledge domain that teachers must possess to integrate technology in teaching. This, in turn, implies that contextual knowledge is something that teachers of biology can act on, change, and develop. Just as teachers of biology seek to develop teachers' knowledge types and overall TPACK, it becomes clear that teachers ought to work toward increasing their contextual knowledge as well. Contextual knowledge therefore becomes of critical importance to teachers, and a lack of it limits the effectiveness and success of any TPACK development and teacher's attempts at technology integration. This outer dotted outer circle is named XK for "conteXtual Knowledge" in order to distinguish it from content knowledge (CK). Mishra (2019) notes that using X for conteXtual is very appropriate because X usually denotes a variable, and contextual knowledge often is highly variable.

The theory implies that the balance of technology, pedagogy and content knowledge are essential for success in effective teaching for learning biology using ICT. It's evident that the teacher should have acquired knowledge of the content, pedagogy and technology. These are confined in the teacher while availability of ICT is also essential for them to be used and these forms the selected factors. The outer dotted circle encloses a space but it is not designated as a form of knowledge. It is labelled "Context" or "Contexts." Since TPACK is a framework for teacher knowledge, maintaining semantic consistency requires that every enclosed space represent some aspect of teacher knowledge. That works for TK, PK, and CK (and the overlaps, TCK, PCK, TPK, and TPACK) and should for the outer dotted circle too. The TPACK theory has excellently explained interaction of the three spheres of knowledge and how they blend to enable a teacher of biology integrate ICT in teaching. Though this theory has an excellent explanation of how technology is integrated in teaching biology, it does not candidly address how knowledge is formed from existing knowledge. There is therefore a need to adopt another theory to address how knowledge is formed from the existing knowledge. The most appropriate theory is the constructivism theory. The researcher has therefore adopted the constructivism theory as the second theory.

2.12.2 Constructivism Theory

According to Osborne and Witrock (1985) many early educators point to the fact that learning is a constructed process. Vygosky (1978) and Cahyadi et al. (2022) notes that it is grounded on the epistemological belief that the world does not have inherent meaning but human beings impose meaning on the world itself. Constructivists believe that learning is construction of

knowledge obtained from one's experiences rather than directly receiving information from the outside world (Resnick, 1987). Constructivism therefore, refers to a learning approach that emphasizes the importance of experiential exploratory learning. It is evolved from the writings of Lev Vygotsky of 1978 that focused on the relevance of direct meaningful knowledge construction through experience of the world (Edelen & Skukauskaite, 2022). Bruner (1990) defined constructivism-learning theory as an active construction of new knowledge based on a learner's prior experience or existing schemas. Further, Bruner (1990) expounded that it is a learning process in which the learner builds on present and previous information.

Constructivists emphasize critical thinking, problem solving, authentic learning experiences, social negotiation of knowledge, and collaboration pedagogical methods that change the role of teacher from disseminator of information to learning facilitator, helping students as they actively engage with information and materials to construct their own understandings (Temsah & Safa, 2021). Both the knowledge frameworks of students (prior knowledge) and of the knowledge domains relevant to the learning activities must be considered in the integration of ICT. Talsma et al. (2021) posits that the appropriate use of ICT by students can assist teachers in determining and catering for the prior knowledge of students. Furthermore, it is argued that ICT can assist students in engaging cognitively to a greater depth with knowledge domains. That is, students are supported in employing the full range of thinking skills within authentic contexts. This is often discussed in terms of cognitive taxonomies such as that provided by Bloom (1964). Makur et al. (2023) asserted that an educator who believes in constructivism should be concerned with personal conceptual frameworks, prior knowledge, students' understandings, the relationship of formal knowledge to spontaneous frameworks, and the attitude of the learner to formal knowledge.

Park and Shin (2021) and Xu (2019) argued that a belief in constructivism will determine the type of computer software used in classrooms and the manner in which computer-use is integrated with the curriculum and implemented in the classroom. Li-Ping and Ahmad (2022). on the other hand, described constructivism in terms of four facets which are also referred to as principles. The first facet of constructivism is that meaningful learning is the active creation of knowledge structures from personal experiences. This suggests that learning occurs when people use their existing knowledge to understand and explain new ideas. They further explain that the second facet of constructivism is that it rejects standardization of curriculum and promotes customization based on the student's prior knowledge. Constructivism does not

speculate a total transfer of knowledge from one person to another since individuals interpret and make meaning of them. It advocates the principles of multiple realities. Constructivism disputes assessment based on standard tests, and promotes testing which is part of the learning process. The third principle of constructivism maintains that the truth is "in the mind of the beholder" (Li-Ping and Ahmad, 2022). In other words, though people may generally disagree on an issue, since they interpret their own meaning, which is influenced by their environment, they can have their own specific explanations for any issue.

The final facet of constructivism is that there is formation and changing of knowledge structures. Constructivist principles involve an open-ended environment, where learners get greater control of the learning process. According to social constructivism, learning generally is a socially mediated activity (Li-Ping & Ahmad, 2022). Applying Vygotsky's theory of constructivism to the use of technology in the classroom, Li-Ping and Ahmad (2022) argued that ICT tools can play a crucial role in facilitating teaching. ICT can be used to link a teacher of biology to more knowledgeable peers and experts in the teaching area. Such a relationship mediated through ICT based modes of communication is referred to as tele-apprenticeship (Li-Ping & Ahmad,2022). ICT-based modes of communication also help learners create strong relationships with mentors, experts and peers. Constructivism is the assimilation of experimentalist, humanistic, behaviorist and cognitive ideals and theory. The constructivist stance maintains that learning is a process of constructing meaning. According to Annuar et al. (2021) it is how people make sense of their experience. When applying this theory in teaching of biology, it is essential to understand that we need to consider the cultural environment in which this learning takes place. Moreover, according to Alismaiel et al. (2022) constructivist-learning approach involves educators building school curriculum around the experience of their students which includes the existing technology.

According to Sari (2019) Constructivists believe learner-centered instructional classroom methods will strengthen the commitment and involvement of self-motivated learners because of their high level of interaction. This theory addresses the gaps and demonstrates how knowledge is built. This will enhance better working as the teacher will not strain to explain the concepts in biology. The teacher should be well versed with pedagogical knowledge on which he/she will build on the ICT use. It's also important that the teacher has technological knowledge that will enable him/her to integrate the ICT. The use of the two theories informs how ICT is integrated in biology teaching.

2.12.3 Diffusion of Innovation Theory

This the third theory in the current study that has attempted to explain the management of the process of integration of ICT in public secondary schools. This theory is a set of generalizations regarding the typical spread of innovations and trends within a social system such as schools and therefore explains why some innovations are adopted while others are ignored. The founder of the theory is Everett M. Rogers in 1962 in his book called Diffusion of Innovations. Curtis (2020) describes diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system while an innovation is an idea, process, practice or device perceived as new by an individual or social unit of adoption. Frei-Landau et al. (2022) concludes that diffusion therefore can be seen as a process that happens through the interpersonal communications, media, and other social networks in which people interacts with.

This theory has identified four factors that influence the adoption of an innovation such as ICT. The factors are innovation itself, the communication channels used to spread information about the innovation, time, and nature of the society to which innovation is introduced. In support, Nella et al. (2022) identifies five attributes of innovations that help to explain different rates of adoption. First, the innovation must have some relative advantage over an existing innovation or the status quo. Therefore, if an individual perceives that the innovation has greater advantages, then its adoption will be faster. Second, the innovation has to be compatible with existing values, experiences and needs for potential users such as teachers. Third, the innovation must not be perceived as too complex for the person using it. This is because new ideas that are easy to comprehend are adopted more rapidly than those that require new skills. Fourth, the innovation must have trial ability for it to be tested for a limited time without adoption. Trial ability provides individuals with less uncertainty and gives them an opportunity to learn and practice by doing. Lastly, the innovation must offer observable results which should be better than existing one. If an innovation shows positive results, the possibility of its adoption is enhanced.

Curtis (2020) and Rogers (1995) asserts that the decision to accept an innovation is not authoritative or collective but members of a social system faces five stage innovation-decisions process. The first stage is called the knowledge stage. In this stage, potential adopters of an innovation must first learn the innovation and know how it functions. In the second stage, the potential users must be persuaded that there are merits of the innovation before they adopt it. In the third stage the adopters of the innovation must make a decision to either adopt the

innovation or not. The fourth stage is the implementation stage where users put the innovation into actual use. Finally, the users must confirm that their decision to adopt the innovation was appropriate. When an individual has gone through these stages, the diffusion of the innovation is said to have taken place.

Diffusion of innovation theory and management of the ICT integration in public secondary schools

According to Sherry and Gibson (2002), one of the most popular models in management of innovation is described by Everett Rogers in his book, Diffusion of Innovations. Rogers (2003) defines diffusion as the process in which an innovation is communicated thorough certain channels over time among the members of a social system. He further notes that technology is composed of two parts hardware and software. Rogers observed that since software has a low level of observability, its rate of adoption is quite slow as compared with the hardware. The theory notes four key components of the diffusion of innovations which are innovation, communication channels, time, and social system. An innovation is conceptualized as an idea, practice, or project that is perceived as new by an individual or other unit of adoption. According to Sherry and Gibson, an innovation may have been invented a long time ago, but if individuals perceive it as new, then it may still be an innovation for them. The newness characteristic of an adoption has three steps which are knowledge, persuasion, and decision. Rogers states that diffusion is a specific kind of communication and includes three communication elements: an innovation, two individuals or other units of adoption, and a communication channel. Diffusion is a very social process that involves interpersonal communication relationships" (Rogers, 2003). Thus, interpersonal channels are more powerful to create or change strong attitudes held by an individual. In interpersonal channels, the communication may have a characteristic of homophily where two or more individuals who interact are similar in certain attributes, such as beliefs, education and socioeconomic status but the diffusion of innovations requires at least some degree of heterophily, which is "the degree to which two or more individuals who interact are different in certain attributes. Medlin (2001) notes that one of the most distinctive problems in the diffusion of innovations is that the participants are usually quite heterophilous.

According to Rogers (2003), the innovation-decision process involves five steps: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages typically follow each other in a time-ordered manner. The innovation-decision process

starts with the knowledge stage. In this step, an individual learns about the existence of innovation and seeks information about the innovation. “What?,” “how?,” and “why?” are the critical questions in the knowledge phase. During this phase, the individual attempts to determine “what the innovation is and how and why it works” (Rogers, 2003). According to Rogers, the questions form three types of knowledge: (1) awareness-knowledge, (2) how-to-knowledge, and (3) principles-knowledge. Rogers identified five characteristics of innovations: (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability. According to Sprague et al. (1999), the biggest barrier to teachers use of technology in teaching was that they lack a vision of why or how to integrate technology in the classroom. teachers usually seek it from trusted friends and colleagues whose subjective opinions of a new innovation are most convincing.

Wanjala (2013) in a study on teachers’ perceptions on the use of ICT in the administration of public secondary schools in Kimilili Sub-County, Bungoma County, Kenya used the Diffusion of Innovations Theory. The findings of the study revealed that basic ICT hardware and software were not adequate for use in performing administrative tasks in the sampled schools. Even though the teachers were willing to fully embrace ICT in administration, its use in administration was limited to very few administrative tasks due to inadequacy of hardware or absence of relevant software. The rationale behind using this theory was that, it was useful in understanding the technological innovation and how its attributes influence school managers to integrate technology, the innovation-decision processes and the stages involved, the innovativeness and technological needs of different adopter categories (the early adopters and late adopters), communication channels used by individuals to share information related to technology adoption; and organization unit of the social system and how it influences technology adoption (Mutisya, 2014) . In this study, the diffusion of innovation theory shows that principals should provide relevant ICT resources to the teachers, mentor them by integrating ICT.

Decision level involves supervising teachers of biology use ICT which includes encouraging the teachers of biology to deliver content using ICT. To start with planning is one of the management functions of a school principal. The principal will exercise this function by ensuring the school plan for use of ICT in teaching in addition the teachers will prepare for teaching using existing ICT tools. During supervision process, the principal who is the instructional head, will see to it that the teachers of biology will use ICT during content delivery, for assessment of learners and record keeping which is information storage.

Organizing is another core management function that a principal carry. In a school, the principal will provide the required ICT resources for effective teaching. During the process, principals reflect on the advantage and effectiveness of integrating ICT in management of schools and as a result express their readiness towards ICT integration. In this study, the attributes that affect diffusion of an innovation as identified by Chukwu and Eneje (2021) were applied. The attributes in the theory provide an outline that helps in understanding why some principals facilitates integration ICT in their schools while others do not (Mutisya, 2014). The diffusion theory can be used to explain, visualize and account for factors that enhance or hinder the integration of ICT in the management of use of technology in public secondary schools. This theory was found very appropriate for the study because it explains influence of personal and school factors on the integration of ICT in biology teaching in public secondary schools. The principal who is the curriculum implementation head has a huge task to integrate the ICT and he/she mentors the staff in his school in addition to supervision of the integration.

According to this theory, the principal should persuade teachers of biology through sensitization about the new innovation before adopting it for use in teaching. The theory further explains that some teachers who are slow in taking up the new technology and applying it should be supervised closely by the principal. Other teachers who have already adopted the technology and are enjoying the benefits should be encouraged and commended to continue using ICT in biology teaching. The early adapters can also be tasked to mentor late adapters and laggard group of teachers. The theory provides an understanding of how to introduce new ideas into the social system, organize them and sustain them through regular monitoring. Finally, the theory depicts that principals should provide adequate ICT resources for teachers to be able to integrate them. The theory was therefore considered applicable in the current study on investigation of influence of personal and school factors on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

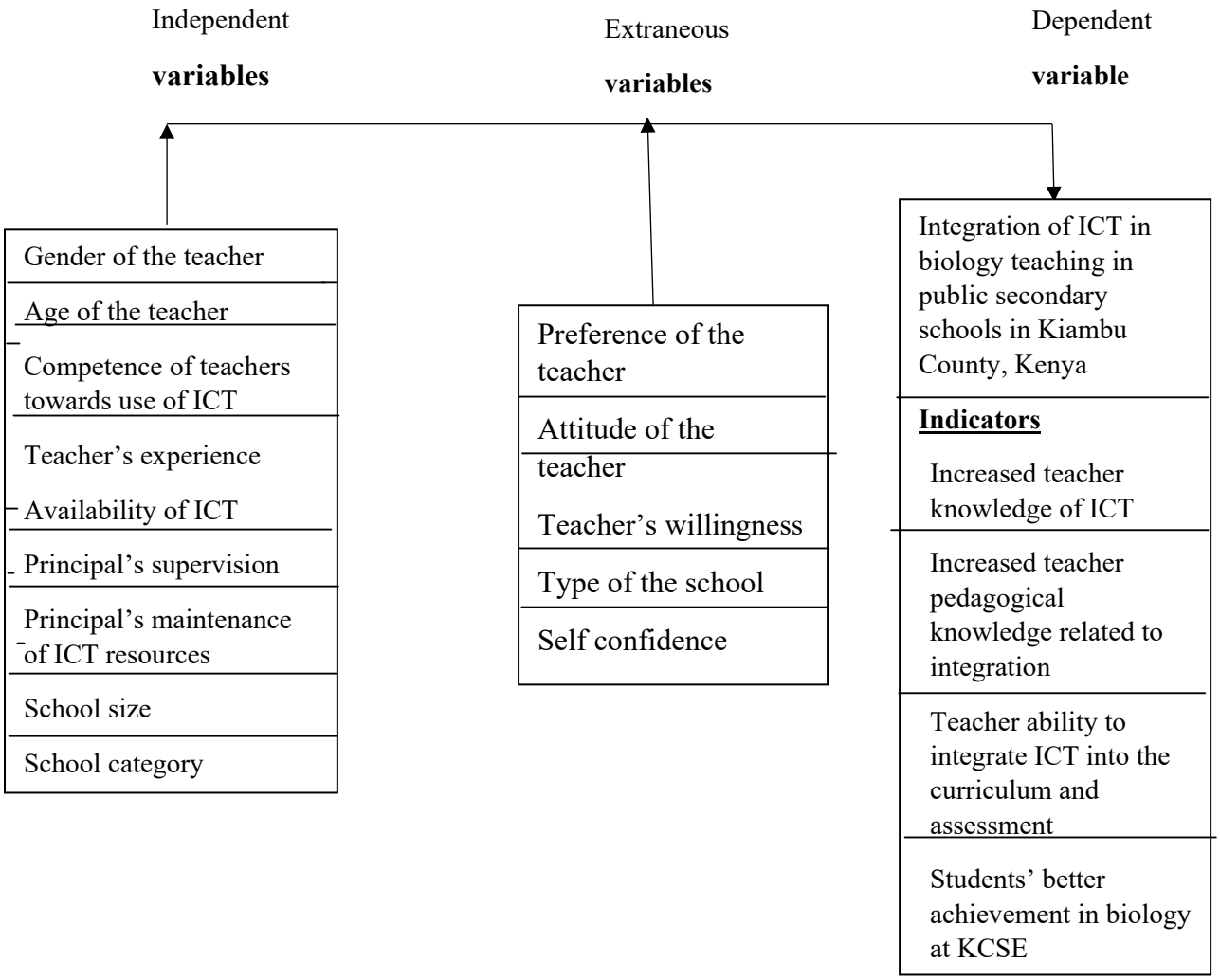
2.13 Conceptual Framework

This study was based on the premise that integration of ICT in teaching is essential to teaching in secondary schools. The study presumed that integration of ICT in teaching (dependent variable) is influenced by gender of the teacher, age of the teacher, competency of the teacher, experience, and availability of ICT towards use of ICT (Independent variables) principals' level of supervision, principals' level of maintenance of ICT resources, school size and school category. It further postulated that the extent to which the aforementioned independent variables may influence integration are moderated by preference of the teacher, attitude of the

teacher, willingness of teachers, type of the school and self-confidence of the teacher (moderating factors). These were the factors that interacted in favour of the integration of ICT in biology teaching in secondary schools and may not be controlled by the researcher. The conceptualized relationship between independent, dependent and extraneous variables is summarized in Figure 2.3.

Figure 2.2

Interrelationship between Variables Subsumed in the Study



CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the methodology that was used to attain the objectives of the study. It presents the research design, location of the study, target population, sample size and sampling techniques, instrumentation, validity and reliability, data collection procedures, data analysis methods used and ethical considerations in research.

3.2 Research Design

A design is an overall systematic plan on collecting, organizing and analyzing of the data in a study (Creswell, 2010). The study adopted the *ex-post facto* research design. An *ex-post facto* research design integrates different methods in collecting data required in a study (Plowright, 2011). According to Kothari, (2011) and Wittrock (2000) the design includes reporting what has happened or happening without interfering with given variables. Kothari asserts that, it is also concerned with describing, recording and reporting conditions as they exist. Kothari concludes that in *ex-post facto*, a researcher can generally discover causes even when he/she cannot control variables. This study explored the influence of selected factors on integration of ICT in biology teaching in public secondary schools in Kiambu County. These factors are teacher's gender, age, competency, experience, availability of ICT, level of supervision, level of maintenance of ICT resources, school size and school category. This design was found to be appropriate for the current study in view of the fact that integration is an activity that may have happened in some of the schools while in others it is ongoing.

3.3 Location of the study

The study was carried out in public secondary schools in Kiambu county which is located in the Nairobi metropolitan region of Kenya. Kiambu County is number 22 in Kenya according to the constitution of Kenya (GoK, 2010). The county has 12 sub-counties (Appendix I). The

county borders Nairobi and Kajiado counties to the South, Machakos to the East, Murang'a to the North and North- East, and Nyandarua to North- West. The rationale of choosing the County was grounded on the fact that inspite of having many public secondary schools in all the categories (national, extra- county, County and Sub-County), being a County in metropolitan region and being richly endowed with many resources, no available evidence of a study that has been conducted to determine influence of personal and school level factors on the integration of ICT in biology teaching in public secondary schools in the county. In addition, the County attracts a large number of personnel teachings there due to its proximity to the capital city and improved infrastructure. Lastly the county has not integrated the ICT as per ministry of education policy hence it's a rich place to collect data.

3.4 Target Population

The target population in this study was teachers of biology and principals in public secondary schools in Kiambu County. This is because the study focused on the integration of ICT in biology teaching in public secondary schools. The target population was 812 both teachers of biology and principals divided as follows; 521 teachers of biology and 291 principals in Kiambu County teaching in 291 public secondary schools which have up to form four and taking KCSE (see Table 3.1). Given the nature of the problem under investigation, that is influence of personal and school level factors on integration of ICT in biology teaching in public secondary schools, the study used teachers of biology and principals as units of study due to the fact that they were the point of focus and they were the ones expected to integrate the ICT in biology teaching while the principals are supposed to manage the teachers of biology and the process of integration of ICT. Teachers of biology and principals were therefore the best respondents to give data pertaining integration of ICT in teaching the subject and management of the process. The study specifically utilized the school principals to obtain data pertaining influence of supervision, maintenance, school size and school category on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

Table 3.1

Distribution of Target Population

School Category	Principals	Teachers of Biology	Total
National	06	32	38
Extra-County	19	76	95
County	53	109	162
Sub-County	213	304	517
Total	**291**	**521**	**812**

3.5 Sample Size and Sampling Procedure

3.5.1 Sample Size

Ary et al. (2006) define a sample as a small group obtained from accessible population. On the other hand, Orodho (2009) simply defines a sample as a sub-set of a population. In order to represent salient characteristics of the accessible population and to reduce sampling error, a sample must be large enough (Mugenda & Mugenda, 2012). The researcher used Krejcie and Morgan (1970) table of determining sample sizes for different populations to determine the sample size for this study (See Appendix E). The sample size of this study was 260. The researcher sampled a total of 93 principals and 167 teachers of biology in the County. The sample was obtained from National, Extra-County, County and Sub-County schools within Kiambu County. The number of principals and teachers used in the study was selected proportionately to the number of public secondary schools. The researcher calculated the proportion of principals to be used by dividing the total number of principals (291) by the target population (812) and then multiplying by the sample size (260). This gave a total of 93 principals as the sample of principals.

To get the number of principals in each category the researcher divided number of principals in a category with the total number of principals (291) and multiplied with 100% which gave 36%. The researcher then selected 36% of principals from each category. The sample teachers(n=167) of biology were obtained by dividing the sample 260 teachers of biology with 812 and then multiplied with 100%. This gave 32%. The researcher then selected 32% of

teachers of biology from each category which in total gave the sample size. From the above formula, the following principals per category were obtained. National schools two principals, Extra-County six principals, County schools 17 principals and Sub-County Schools contributed 68 principals. This gave a total of 93 principals. The researcher also sampled 167 teachers of biology as follows; ten from National schools, 24 from Extra- County schools, 35 from County schools and 97 from Sub-County schools.

3.5.2 Sampling Procedure

According to Kothari (2011) and Mugenda (2011) sampling is a research technique used for selecting a given number of subjects from a target population. Stratified random sampling method and simple random sampling were used to sample 93 public secondary schools. All the public secondary schools in the County were placed in four strata namely, National, Extra-County, County and Sub-County. The public secondary schools were then selected from each stratum by use of simple random sampling method. There were six National schools, 19 Extra-County, 53 County schools and 213 Sub-County public secondary schools in the County hence a total of 291 public secondary schools taking KCSE. The sample included two National schools, six Extra-County, 17 County and 68 Sub-County public secondary schools. Therefore, a total of 93 public secondary schools were sampled (Krejcie & Morgan,1970). Teachers of biology in these schools were used as the study units. The teachers sampled were teaching biology at the time of collecting data and were sampled purposively. The researcher purposively sampled teachers of biology where in a school with only one teacher, he/she was sampled.

In schools with more than one teacher of biology, the researcher selected the ones who were teaching form three at the time of collecting the data. However, schools from extra- County and county with more than three teachers teaching biology in form three, the researcher selected three teachers only. For the national schools the researcher purposively sampled five teachers of biology from each of the two national public secondary schools. The researcher used simple random sampling to select five teachers from national schools category and three teachers in county and extra-County categories. The researcher assigned numbers to the form three teachers teaching biology and placed them in a basket and selected any three for county and extra- county and for national schools, he selected any five. The teachers selected, responded

to the questionnaire used in this study. Table that follows give the information on sample of teachers of biology and principals in the study.

Table 3.2

Sampling Frame

Category of respondents	Category of schools	Total (N)	Sample (n)
Schools	National	06	02
	Extra- County	19	06
	County	53	17
	Sub-County	213	68
Total		**291**	**93**
Teachers	National	32	10
	Extra-County	76	24
	County	109	35
	Sub-County	304	97
Total		521	167
Principals	National	06	02
	Extra-County	19	6
	County	53	17
	Sub- County	213	68
Total		**291**	**93**

Table indicates that, a total of 93 schools were selected for the study out of a total of 291schools. Majority of the schools were Sub-County that is 68. This is because Sub-County public secondary schools are majority in the County as compared to the other categories. The second were the Extra-County schools which gave six schools while County category contributed 17 schools and eventually the Sub-County category gave 68 public secondary schools. (Krejcie & Morgan,1970).

3.6 Instrumentation

The instruments used in the study were questionnaires. The researcher used teachers and principals questionnaires. The objectives of the study formed the basis on which, the research

instruments were constructed. The instrument was developed so as to contain all the items that would aid in achieving the objective of the study as stated in chapter one. The study answered the question on the influence of personal and school level factors on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. The respondents were required to respond on influence of gender, age, competency, teaching experience of teachers of biology, availability of ICT, supervision of the principals, maintenance of ICT, school size and school category on integration of ICT in biology teaching in public secondary schools in Kiambu County. Instruments used in the study were questionnaires containing structured and closed ended questions.

The questionnaires were directed to the principals and teachers of biology in public secondary schools in the county. The questionnaires were administered to various school principals and teachers of biology. The instruments were developed so as to contain all the items that would aid in achieving the eight objectives stated. Self-constructed research instruments were used in the study. The instruments were teachers of biology questionnaire and principals' questionnaire. The instruments enabled the researcher to collect sufficient data that was required for the study. The instrument used was the questionnaire.

3.6.1 Questionnaires

Teachers' questionnaires (TQ) and principals' questionnaires (PQ) were the data collection tools utilized for the study. The teachers' questionnaire (Appendix B) consisted of 16 items. The questionnaire translated the objectives of the study into specific questions. The closed-ended items were utilized to gather data required for study. The teachers' questionnaire was divided into four major sections. Section A collected data on gender, age and teaching experience of the respondents while section B collected data pertaining availability of ICT resources in sampled schools in biology teaching. Section C collected data on competency while section D collected data on integration of ICT resources in sampled schools. The teachers' questionnaires therefore gathered information related to influence of selected factors on integration of ICTs in biology teaching in public secondary schools in Kiambu County. Only sampled teachers of biology from public secondary schools participated in the study by filling in the questionnaires.

The principals' questionnaire (PQ) had four (4) sections. Section A collected data on supervision of teachers and its influence on integration of ICT in biology teaching in public secondary schools in Kiambu County. Section B collected data on maintenance of ICT and its influence on integration of ICT in biology teaching in public secondary schools in Kiambu County. Section C collected data on size of the school and its influence on integration of ICT in biology teaching in public secondary schools in Kiambu County. Section D collected data on influence of the category of the school on integration of ICT in public secondary schools in Kiambu County. The reason for using the questionnaires in this study is that, they were convenient to administer when handling a relatively large group of respondents from a wide and distant geographical area. In addition, they were cost effective and did not interfere with confidentiality of the respondents as they don't disclose their identity. They also collected a lot of data. (Mugenda & Mugenda, 2012).

3.7 Validity and reliability

3.7.1 Validity

According to Orodho (2009) Validity is the extent to which an instrument measures what it purports to measure. Kothari (2011) elaborates that it is the degree of agreement between the claimed measurement and the real world. Creswell and Creswell (2017) noted that validity is gathering of evidence supporting inferences to be made on the basis of the scores obtained from the operations of measurement. Wilson et al. (2012) concludes that validity is the extent to which your measurement procedure was measuring what you think it is measuring and whether you have used and interpreted the scores correctly.

Two types of validity were considered while developing the research instrument. These were content and face validity. Content validity refers to the representativeness of items on the instrument as they relate to the entire domain or universe of the content being measured (Mugenda & Mugenda, 2012). This type of validity was enhanced subjectively through examination of the instruments by experts in Laikipia University School of Education (SoE) on whether the questionnaire covered all relevant items needed to achieve the research objectives as stipulated in chapter one of the proposal. Face validity refers to the appearance of instrument. It was enhanced by subjecting the questionnaires to the Subject Matter Experts (SME) scrutiny. The experts looked at whether each question in the questionnaire was essential. According to Wilson et al. (2012) the panel of SME should answer whether the intended question is relevant to the intended research issue. The experts who are also the supervisors

after several reviews with incorporating their comments they okayed the questionnaires for the use in the study.

3.7.2 Reliability

Reliability is the measure of the degree to which a research instrument yields consistent results or data after repeated trials in different settings (Gronlund ,1985; Kothari, 2011; Mugenda & Mugenda, 1999). According to Kothari (2011), a measuring instrument is reliable if it provides consistent result. Christensen et al. (2015) observed that reliability refers to the consistency or stability of the scores of your measurement instrument. Therefore, for a research instrument to be reliable, it must be capable of yielding consistent results when used more than once to collect data from two samples drawn randomly from the same population. Test-retest method was used to test the reliability of questionnaires. Researcher carried out test-retest study in four schools in Kiambu County which were not sampled for the study. The researcher used a school from each category (National, Extra-County, County and Sub-County). From each school, the principal and a teacher of biology were selected and given the questionnaire to fill in.

The following test, re-test techniques were undertaken: (i) The developed questionnaires were given to a sample of four teachers of biology (ii) The answered questionnaires were scored manually (iii) The same questionnaires were administered to the same group of respondents after a period of two weeks. (iv)The questionnaires responses were scored manually again. (v) A comparison of both results was made. Adjustments were made on the instruments to ensure that the instruments were reliable at Pearson's coefficient r' of 0.792 for the teacher of biology questionnaire and r' of 0.771 for the principals. This authenticated the reliability of the instruments.

3.8 Data Collection Procedure

The researcher first obtained a letter of introduction from the graduate school, Laikipia University that was given to the ethics department together with the research proposal for review. The research ethics department gave a recommendation letter after the review of the proposal for the researcher to obtain research permit from the National Commission of Science, Technology and innovation (NACOSTI) before embarking on the process of data collection. The National Commission of Science, Technology and innovation (NACOSTI) gave a research permit to the researcher and a copy of a research authorization letter. The researcher visited the office of County Director of Education in Kiambu and presented a copy of research

authorization letter. The CDE gave a clearance so that the research could be taken in his area of jurisdiction. The researcher then visited the sampled schools and went to the principal's office sought permission for collecting data in the school. When the permission was granted, the researcher made arrangements with the school authority on when to collect the data in the respective schools. The researcher further purposively sampled teachers of biology teaching form three and issued the questionnaires.

A follow-up was made through telephone calls to confirm whether the questionnaires were filled in. The questionnaires were collected after two weeks. The researcher personally distributed and sought the help of a research assistant who distributed the questionnaires to four sub-counties which the researcher felt were far. The research assistant was inducted well to ensure he didn't bleach the ethics of the research. The two-week period gave the respondents enough time to answer all the items in the questionnaire and apparently a high rate of return (87%) was realized.

3.9 Data Analysis methods

According to Kothari (2011), mass data collected during the research process may have little meaning unless the investigator summaries it into a form that is analysable for the purpose of writing the final report. In this regard, raw data collected by use of questionnaires were converted into codes where each code represented a response category and manually transferred to code sheet. Data analysis was carried out through descriptive and inferential statistics that included frequencies, arithmetic means, percentages, t-test, Analysis of Variance (ANOVA), Pearson correlation, regression analysis and simple regression based on the research questions of the study. The Statistical Package for Social Sciences (SPSS) version 26, computer-based program was used as a tool for data analysis. Therefore, Quantitative data collected using questionnaires which formed the bulk of the questions, were analyzed by first coding and inputting coded responses into the computer excel sheet then analyzed by use of SPSS version 26.

The open-ended question in the principals' questionnaire was transcribed and categorized. The coded scores were subjected to t-test and ANOVA to test the significance. Inferential statistics helped to establish whether there was a statistically significant difference between the personal and school level factors and integration of ICT in biology teaching in public secondary schools in Kiambu County. The descriptive statistics was used to present data in form of frequency counts and percentages. Mugenda and Mugenda (1999) notes that inferential statistics helps

the researcher to make inferences about a population based on the results of a representative sample. A summary of data analysis methods has been presented in Table 3.3.

Table 3.3

Data analysis matrix

Research hypotheses	Independent variable	Dependent Variable	Statistical Technique
HO_1: Gender of the teacher has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County	Gender	Integration of ICT in biology teaching in public secondary schools	t-test
HO_2: Age of the teacher has no statistically significant difference on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.	age of the teacher	Integration of ICT in biology teaching in public secondary schools	ANOVA
HO_3: Teacher's competence in use of ICT has no statistically significant influence on the integration of ICTs in biology teaching in public secondary schools in Kiambu County, Kenya.	competency of the teacher	Integration of ICT in biology teaching in public secondary schools	Pearson correlation & Regression analysis
HO_4: Teacher's teaching experience has no statistically significant difference on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.	Teachers professional experience	Integration of ICT in biology teaching in public secondary schools	ANOVA
HO_5: Availability of ICT has no statistically			

significant influence on the availability of ICT integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.		Integration of ICT in biology teaching in public secondary schools	Pearson correlation & Regression analysis
HO_6: Principals' supervision has no statistically significant influence on integration of ICT in biology teaching in public secondary schools of Kiambu County, Kenya.		Integration of ICT in biology teaching in public secondary schools	Pearson correlation & simple regression
HO_7: Principals' maintenance of ICT resources has no statistically Significant influence on integration of ICT in biology teaching in public secondary schools of Kiambu County, Kenya.		Integration of ICT in Biology teaching in public secondary schools	t-test
$H0_8$: Public secondary school size has no statistically significant influence on integration of ICT in biology teaching in public secondary schools of Kiambu County, Kenya.		Integration of ICT in biology teaching in public secondary schools	t-test
$H0_9$: Category of the public secondary School has no statistically significant difference on integration of ICT in biology teaching in public Secondary schools of Kiambu County, Kenya.	school	integration of ICT in biology teaching in public secondary schools	ANOVA

3.10 Ethical issues

Since the study involved human participants, it was imperative that the researcher observed the research ethics involved in planning and execution of the study. According to Orodho (2009),

ethical consideration in research focuses on the application of ethical standards in the planning of the study, data analysis, dissemination and use of the results. The researcher ensured that all ethical concerns were adhered to as follows.

3.10.1 Confidentiality and Privacy

In this study, the confidentiality of the research participants was ensured by taking care of the information given by the respondents and treating it with a lot of confidentiality. The researcher informed all the respondents that the information they gave was neither to be shared to third party nor for other purposes except research. Kamunge (2021) states that, the researcher should not publicize any information that negatively portrays the research participants by revealing their background and social standing and in the current study the researcher did not reveal any details of the respondents.

3.10.2 Anonymity

The researcher assured the respondents that their identity was not be revealed to anybody. Further, no identity information about the respondents or the institution was revealed at all.

3.10.3 Informed Consent and Voluntary Participation

The study involved minimum risk to the participants. However, informed consent was a prerequisite because personal information would be collected from participants. Rubin and Babbie (2008) states that informed consent involves providing participants with information that is likely to influence their decision to participate. This study considered all the four elements of informed consent. To start with is comprehension. The researcher ensured that all participants understood the study before embarking on filling in the questionnaires by allowing them a time of two weeks and room for consultation between the time of request for consent and the decision. Second one is providing full information to the participant. The researcher gave all important information about the conduct of the research. The participants got information on expected benefits of the study, explanation on any enquiries they had and disclosure that participants have right to withdraw consent and dropout of the study at anytime they wished. The third element considered is voluntarism. The researcher made the participant aware that participation in the study was purely on voluntarily base and he/she could turn down the offer of participation or go ahead and participate. The fourth element considered was competence.

3.10 .4 Plagiarism

Plagiarism is deliberate use another person's production without crediting the source or simply copying and putting as own's. In this study all ideas or words that are used from other authors have been properly acknowledged and credited by use of correct citation and referencing.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter constitutes the demographic analysis of respondents, results and discussion based on the objectives of the study. It is divided into several sections. Section two is the response rate of the questionnaire, section three is the demographic analysis of the respondents, section four consists of descriptive analysis based on the objectives of the study while the fifth section presents the inferential analysis based on the objectives of the study.

4.2 The Survey Response Rate

Out of the distributed 260 questionnaires that were physically delivered to the respondents, 226 questionnaires were returned by the researcher picking them from the schools. This represented 86.92 % response rate. The high response rate was contributed by taking questionnaires physically to the respondents, having clear instructions, assuring the respondents on their confidentiality and questions being short and precise. The study sampled 93 principals and 167 teachers of biology. In this regard, a total of 260 questionnaires were physically delivered to the schools sampled. The study received back 226 questionnaires in total as per required sample of the study. This represented 86.92% response rate. Table 4.1 shows the respondents per category.

Table 4.1

***Response rate per School Category*.**

		School category				
		Sub-county	County	Extra county	National	Total
Type of respondent	Principals	68	17	6	2	93
	Biology teachers	74	30	24	5	133
Total		142	47	30	7	226

According to Mugenda and Mugenda (2009), a response rate above 70 % is rated as very well, 60 % good, and 50 % is termed as adequate. The response rate for this study was 86.92 % and therefore very well. Fraenkel *et al*. (2012), sums up by stating that a response rate of more than 60% is considered good for a study.

This information is also depicted by Figure 4.1 that follows.

Figure 4.1

Respondents per School Category

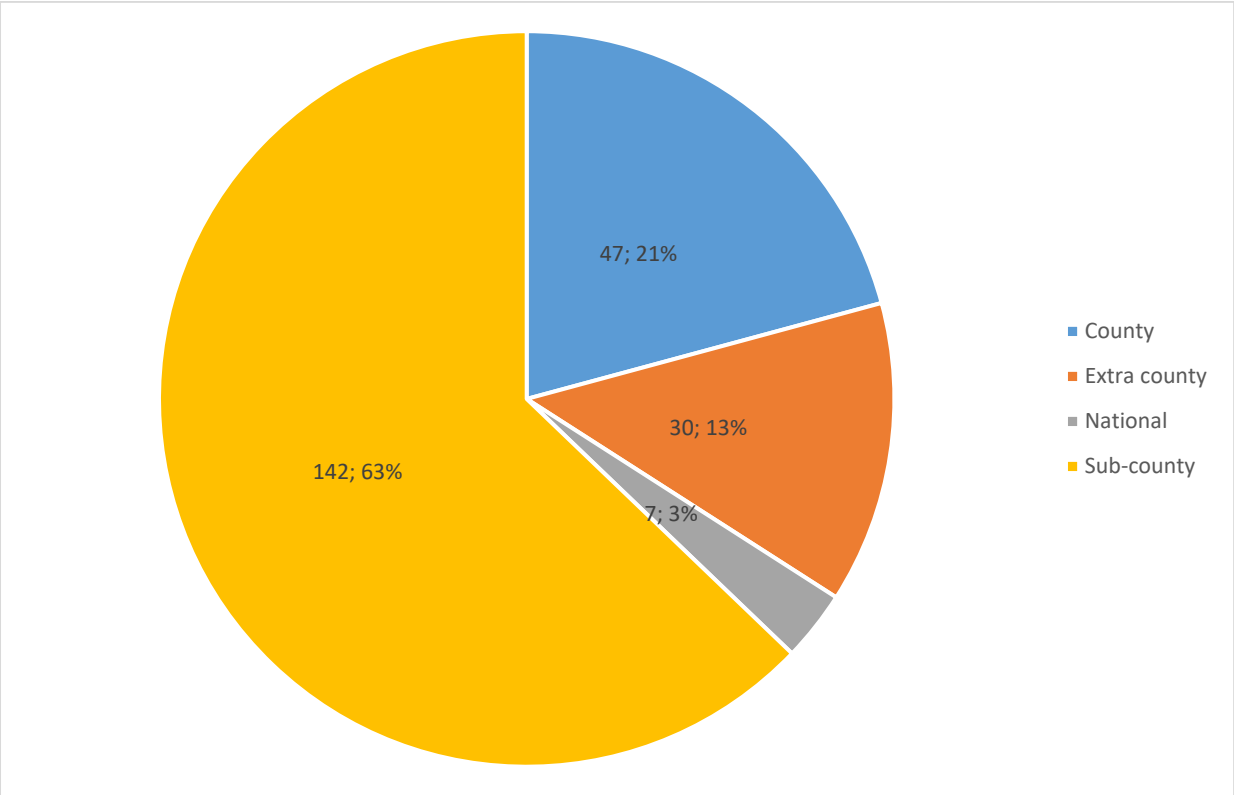


Figure 4.1 indicates that majority of the returned questionnaire were from sub-county school which was 63%, county schools gave 21% while extra-county contributed 13% and national schools gave three percent. The sub-County schools gave the highest number since they were the highest proportionately and the other categories followed. This was within the expectations of the researcher.

4.3 The Demographic Analysis of the study

The demographic characteristics included, the age of teachers of biology, gender of the teachers of biology; highest academic qualifications and years of working experience of the teachers of biology. The demographic analysis was very important in understanding of teachers of biology distribution in public secondary schools in Kiambu County.

4.3.1 Age of the Respondents

Age was clustered into four categories each with an interval of ten years. The age was distributed from 20 to 60 years as seen in Table 4.2. This was done to ensure that the study would capture the young and the old teachers of biology for the study.

Table 4.2

The Distribution of Age of the Teachers of Biology

		School category				
		Sub-county	County	Extra county	National	Sub-total (%)
Age	20-30 Years	35	7	9	0	51(38)
	31-40 Years	25	13	9	1	48(36)
	41-50 Years	12	8	3	3	26(20)
	51-60 Years	2	2	3	1	8(6)
Total		74	30	24	5	133(100)

The results in Table 4.2 shows the distribution of age of teachers of biology in Kiambu County. From the analysis, it can be observed that 38 per cent (n=51), 36 per cent (n=48), 20 per cent (n=26), and 6 per cent (n=8) for 20-30 years, 31-40 years, 41-50 years, and 51-60 years respectively. The data clearly shows that, majority of teachers of biology in the National schools were between 41-50 years. In Extra-County schools, most of teachers of biology were below 40 years. County Schools had majority of teachers of biology aged between 31-40 years while in Sub-County schools most of the biology teachers were under 30years. The teachers of biology mean age was 34 years.

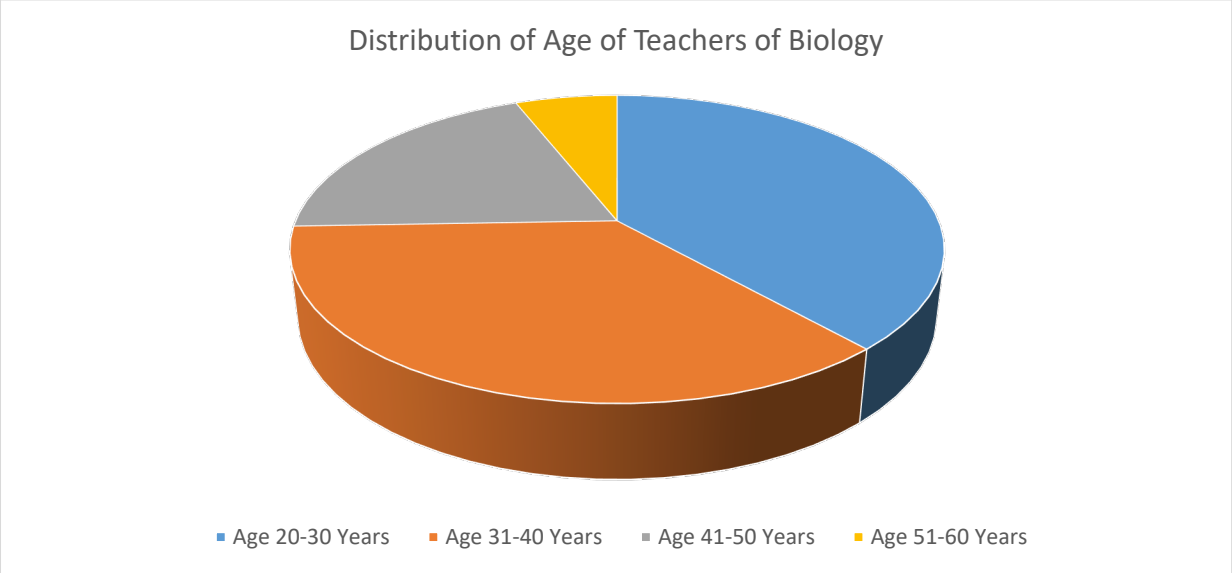
Age is a factor that can influence integration of ICT in teaching. In reference to ICT integration, there has been an existing myth about there being a generational gap related to ICT use such that the rising generations are said to be ‘digital natives’ in contrast to their elders who are said to be ‘digital immigrants’ (Prensky, 2001). In this study, it was found necessary to determine the age differences among teachers and see whether they in any way accounted for their use and integration of ICT in schools. The researcher therefore sought to establish the respondents’ age bracket distribution. The age characteristic is likely to show the physical maturity rate of teachers of biology in public secondary schools in Kiambu County. Majority of teachers below 35 years of age teach in Sub-County schools. These age brackets comprise a group that is defined as youth. Engel (2021), reports that youth within a similar age bracket of 18-35 years

in the Republic of Korea, the United States of America and Australia are more responsive and attracted to ICTs than people of a different age bracket. According to Sung, (2024) people who fall within the ages of 18-35 are youth. It is therefore possible to argue that most teachers who currently teach in Sub-County public secondary schools in Kenya are in their youth hence the need to see their active role in bridging the generational digital gap that might be existing in schools.

Abubakar et al. (2023) observed that teachers in the age range under 40 years are found to be more knowledgeable and skilled in ICT compared to those above 40. Considering that ICT penetration in secondary schools in Kenya began in the late 90s, almost all of the teachers who were 35 years or less must have found computers in their working stations or even must have had pre-service training prior to being employed as teachers hence the need to see them effectively integrating ICTs in instruction. It is therefore expected that teachers of biology who are below 40 years of age, integrates ICT more readily than those who are above the same age. The results in the study indicates that there was no significant difference in ICT integration among teachers of biology of different ages. Figure 4.2 gives a pictorial representation of the age distribution of teachers of biology in public secondary schools in Kiambu County.

Figure 4.2

Age of Teachers of Biology



4.3.2 Gender of the Respondents

The gender of the respondents is categorised as male and female. The distribution of respondents according to gender is shown in Table 4.3.

Table 4.3

The Distribution of Teachers of Biology by Gender and School Category

		School category				
		Sub-county	County	Extra county	National	Sub-total (%)
Gender	Male	37	19	12	0	68(51)
	Female	37	11	12	5	65(49)
Sub-total		74	30	24	5	133(100)

The results in Table 4.3 show the distribution of the gender of teachers of biology in public secondary schools in Kiambu County. From the analysis, it can be observed that 68 (51%) were male. The analysis also shows that 65 (49%) were female. This shows that there was a slightly higher proportion of male than that of female teachers of biology teaching in public secondary schools in Kiambu County. However, there was no much gender disparity in teachers of biology in Kiambu County as male to female representation was 51 per cent and 49 per cent respectively. This is well evident with the equal representation of male and female in both Sub-County and Extra-County schools. For the national schools, no male teacher was sampled. This was by chance and not error since there were male teachers of biology though were not selected since they were not teaching form three by the time of data collection or even though they may have been teaching form three, they were not amongst the three teachers selected per school. Therefore, missing male teachers in the national school sample was by chance. The findings therefore indicate a balanced gender distribution amongst teachers of biology in the county. Ezekiel and Ezekiel (2019) observed that male teachers in Nigeria had relatively higher levels of computer attitude and ability before computer implementation, but there is no difference between males and females regarding computer attitude and ability after the implementation of the technology.

4.3.3 Teaching Experience of Teachers of Biology

The teachers of biology teaching experience were distributed from one year to more than 20 years. It was clustered into four categories each with five years and last category of those who have taught more than 20 years. The information obtained is presented in Table 4.4.

Table 4.4

Distribution of Teachers of Biology by Teaching Experience and school category

		School category				
		Sub-county	County	Extra county	National	Sub-total (%)
Experience in teaching Biology	(1-5) Years	31	5	4	2	42(32)
	(6-10) Years	19	9	8	0	36(27)
	(11-15) Years	14	6	9	0	29(22)
	(16-20) Years	6	3	1	3	13(10)
	Over 20 Years	4	7	2	0	13(10)
Sub-total		74	30	24	5	133(100)

The results in Table 4.4 show the distribution of teachers of biology teaching experience. From the results in Table 4.4, it is observed that 32 % (n=42), 27 % (n=36), 22 % (n=29), 10 % (n=13), and 10 % (n=13) of teachers had taught biology for (1-5) Years, (6-10) Years, (11-15) Years, (16-20) Years, and over 20 Years respectively. Over 65 per cent of teachers of biology from Sub-County, County, and Extra-County had less than 15 years teaching experience. However, 60% of teachers of biology in National schools had taught biology for 16-20 years. Over 65 per cent of teachers of biology from Sub-County, County, and Extra-County had less than 15 years teaching experience. This confirms the notion that teachers in National schools do not transit frequently as teachers in other categories. The teachers of biology mean teaching experience was 9 years. Mutisya (2017), observed that the experience of teachers is a pointer to quality teaching and leadership in instructions. From the information given by the respondents, it can be concluded that most teachers in sub-county schools little experience and can be considered as young professionals since they have more than half of their working time remaining before they retire at age of 60 years (Miima, 2014). while those in Extra- County and National were experienced. In Kenya, the retirement age for teachers is 60 years. The results in the study shows that teachers of biology with 11 to 15 years and those with over 20 years of experience integrated ICT significantly in their teaching.

4.3.4 Teachers of Biology Academic Qualification

The study sought information on the academic qualifications of the teachers of biology. This means the highest level of educational training that one obtained in relation to his/her

qualification as a teacher. The respondents were categorised according to their level of education and the distribution is presented in Table 4.5.

Table 4.5

The Distribution of Teachers of Biology by Academic Qualification and school category

		School category				
		Sub-county	County	Extra county	National	Sub-total (%)
Highest professional qualification	Diploma	13	3	6	0	22(17)
	Bachelors	47	23	14	5	89(66)
	Masters	14	4	4	0	22(17)
	PhD	0	0	0	0	0(0)
Sub-total		74	30	24	5	133(100)

The results in Table 4.5 show the distribution of the academic qualification among teachers of biology in public secondary schools in Kiambu County. From the analysis, it can be observed that all 100% of the teachers of biology were professionally trained. The analysis also shows that all teachers of biology in national schools had bachelor degree qualification. While all the other categories of schools had teachers with more than one degree. There were diploma holders in the national schools unlike the other categories of schools. According to Muia (2022) the higher a teacher progresses in professional training, the more one is likely to be exposed to ICT use and application and subsequently the higher the probability of integration. Mogeni (2020) adds that differences in the teachers' academic qualifications is also seen as a contributor towards teachers' (and hence schools') tendencies to differ in terms of performance level, innovation capacity and affinity to change. Studies have indicated that academic qualification influences the adoption of a new idea (Ndegwa et al., 2023; Bukar & Mustafa, 2020). For teachers to productively integrate ICTs, they ought to be academically qualified to ensure that they know how to and the reasons for interweaving content, pedagogy and technology thoughtfully and successfully (Alharbi, 2022).

According to Mogeni (2020), the minimum requirement for teachers in secondary schools by the Ministry of Education in Kenya is a Diploma in Education, it was interesting to note that all teachers sampled had diploma in education and above. Infact, 18.79 % had postgraduate qualifications. As a requirement, most universities that offer postgraduate degrees in Kenya

require students at that level to use ICTs for various functions including research work, academic writing and for presentations. Mogeni (2020), observes that people who have tertiary qualifications are more likely to be better ICT users than their counterparts with lesser qualifications. It was therefore assumed that the more teachers pursue higher opportunities of learning at postgraduate level, their enhanced ICT skills would be transferred innovatively into instructional practices.

4.4 Descriptive Analysis of the Data Obtained for the Study

In this section, the study analyzed the descriptive results based on respective objective of the study.

4.4.1 The Descriptive Statistics of Competency of the Teacher of Biology in Relation to Integration of ICT.

The study looked on to various aspects that depict competency of the teacher of biology on integration of ICT. To start with, the study looked at the frequency of using ICT to develop instructional materials.

4.4.1.1 Frequency of Using ICTs to Develop Instructional Materials

Teachers' Frequency of integration of ICTs into the instructional processes was a major concern for the study, the researcher sought to establish teachers' frequency of integrating ICT into the development of instructional materials for instructional processes. Frequency of integration of ICTs in this case refers to how often ICTs were being applied in developing teaching materials. The teachers of biology, therefore, were asked to state how often they were using the ICT in their development of teaching materials. One hundred and thirty (N=130) teachers of biology responded to this item as follows.

Table 4.6

Frequency of Use of Computers to Develop Instructional Materials for Biology Teaching

	Not at all		Rarely		Sometimes		Often		Always	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
How often do you use personal computer in preparation of materials for biology teaching	10	7.52%	20	15.04%	77	57.89%	21	15.79%	5	3.76%

The results in Table 4.6 show the frequency of use of computers to develop instructional materials for biology teaching among public secondary school teachers in Kiambu County. From the analysis it can be observed that 10 (07.52%) teachers of biology did not use personal computers at all. 20 (15.04%) rarely used personal computers to develop instructional materials while 77 (57.89%) use their personal computers sometimes. 21 (15.79%) use personal computer often and only 5 (3.76%) use the personal computers always to develop instructional materials for biology teaching. The study shows that the frequency of integration of ICTs into development of instructional materials varied among teachers of biology. However, majority of teachers of biology (92.48%) at least used ICT to develop instructional materials. A minority of teachers of biology (07.52%) never used ICT in developing instructional materials. This calls for a resolute effort by all parties engaged in ICT integration in developing of instructional materials to ensure that teachers are sufficiently equipped and motivated to implement the ICT integration programmes more frequently.

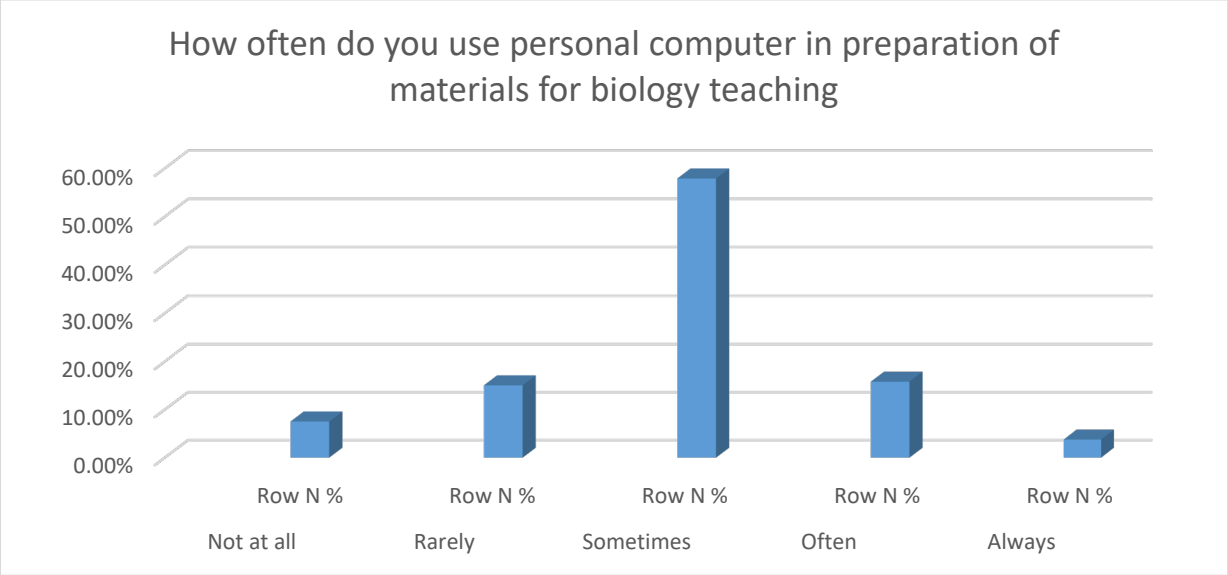
These finding are supported by a study done by Mogeni (2020) that ICT are less often used in the preparation of instructional materials among public secondary school teachers. The study however contrasts a study done by Esfijani, and Zamani (2020) who established that the use of ICT to develop instructional materials for teaching and learning in secondary education was becoming more widespread. The findings of the current study also generally echo assertions that despite the general increase in ICT use world over in the recent years, their use in developing materials for instructions is still poor (Njoki, 2021). Ahmed et al. (2020) noted that despite changes in society, formal classroom teaching is still driven by traditional teaching practices. Saber, (2021) notes that teachers are still using traditional physical instructional materials even in the era of ICT. Mooketsi (2020) adds that many teachers are still widely referring students to hardcopy textbooks for further reading and therefore acting as the information givers instead of facilitators of knowledge acquisition.

In conclusion, Mogeni (2020) emphasizes that integrating ICTs into developing of instructional materials is still a complex process of educational change, and the extent of ICTs application in schools is extremely varied and, sometimes, very limited. In summation Ferede et al. (2022) noted that only a few teachers have meaningfully integrated ICTs and are using them to make significant changes in the classroom including development of instructional materials. The current study and prior studies have shown that majority of teachers do not use the ICTs to develop the instructional materials. This is an area that need to be emphasized since

instructional materials are very essential for meaningful teaching and learning process. This information is also depicted by the Figure 4.3 that follows.

Figure 4.3

Frequency of Use of Computers to Develop Instructional Materials for Biology Teaching



4.4.1.2 Teachers of Biology ICTs Preferences and Uses during Teaching

The researcher sought to establish the teachers' ICTs preferences, and how they were using the ICTs during the instructional processes. Sampled teachers were asked to state the ICT resources and applications (hardware and software) that they preferred using more often than others in their teaching. One hundred and thirty-three teachers of biology answered this question and their responses are summarized in Table 4.7

Table 4.7

Teachers of Biology ICTs Preferences for use During Teaching

	Not preferred		Less preferred		Preferred		Most preferred			
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Mean	Std. Deviation
CDS	7	5.26%	19	14.29%	88	66.17%	19	14.29%	2.89	.699
DVDS	12	9.02%	15	11.28%	41	30.83%	65	48.87%	3.20	.965
Power point	3	2.26%	11	8.27%	27	20.30%	92	69.17%	3.56	.742
Youtube	2	1.50%	9	6.77%	54	40.60%	68	51.13%	3.41	.687
Animations	10	7.52%	55	41.35%	41	30.83%	27	20.30%	2.64	.891
Captions	54	40.60%	37	27.82%	30	22.56%	12	9.02%	2.00	1.000

From analysis in Table 4.7, it can be deduced that Sixty-nine percent (69%) of teachers of biology said their most preferred ICT resource for teaching was PowerPoint, 51.13% most

preferred YouTube 48.87% most preferred DVDs, 20.30%) preferred animations, 14.29% most preferred CDs and only 9.02% most preferred captions. It is scary to note that 49.62% of teachers of biology do not integrate internet related resources in their teaching activities. Most respondents gave multiple responses. PowerPoint was therefore the most preferred ICT resource for use by sampled teachers of biology in Public secondary schools in Kiambu County. Most probably this is because the PowerPoint presentations are easy to use as just require a computer and a projector and no internet connection is required. A projector can be used by a teacher of biology to increase students' engagement by allowing them to collectively participate in presentations such as video, games, content and other group activities all in one session. In addition, a teacher can access different elements of a lesson such as a lesson plan and lesson notes. Teachers may also have preferred the power points due to ease of presentation and has both sound and pictures. YouTube was second most preferred ICT resource by the teachers of biology.

According to Mogeni (2020), in recent years, YouTube application has gained popularity due to the varied content found. In support, Sahdam et al. (2020) did a study on learning through YouTube where the findings showed that 41% of the respondents agreed that they loved learning through YouTube. 38% of the respondents gave a neutral response to the use of videos as being magnificent for classes, and 21% did not agree to this. Such a distinction in percentages specifies that it is still uncommon for students to have their academic education done on YouTube. Such findings concur with those of Mooketsi (2020) who found that 93% of students feel the YouTube process is fascinating. Besides, Fadhil and Ali (2020) supports this view through their interviews with language students. In a study which concluded that the majority of sampled members feel happy and satisfied while watching YouTube videos. The respondents added that they liked YouTube since it had audio and visual effects. The current findings are also in agreement with Miima (2014) who found that Kiswahili teachers in Kakamega County do not prefer using internet resources but instead prefer using digitalized CDs and DVDs.

The findings of this study however, do not agree with a study done by Mavezera (2024). In their studies, Internet related resources and PowerPoint presentations were mostly preferred by teachers. Miima (2014) observed that lot of teaching materials are found on the Internet. Kumar et al. (2022) argue that by connecting computers to the internet in schools, the computers are transformed into powerful communication devices with countless learning applications. There

is need therefore for schools to invest in the installation of internet in schools. Schools' administrations need to be sensitized of the reducing costs of internet connectivity and the attendant advantages offered by the connection. Miima noted the significance of internet by emphasizing that Information found on the Internet could be used by teachers as references to the topics in in the syllabus. Animated graphics could also be used to explain the subject content which may be perceived to be challenging for delivering.

4.4.1.3 Teachers of Biology ICTs Integration Degree of Competence during Teaching.

The researcher sought to establish degree of competence in integration of ICT by the teachers of biology in the sampled public schools in Kiambu County. Teachers of biology were supposed to rank their competence in use of an array of ICT resources in terms of very competent, competent, less competent and not competent. The ICT resources whose competence were sought included CDs, DVDs, power point, You tube, Animations and captions. The summary of the analysis is as shown in Table 4.8.

Table 4.8

Degree of Competency of Teachers of Biology in Integration of ICT

		20-30	31-40	41-50	51-60	Count	%	Mean	Std. Deviation
CDS	Not competent	1	0	1	0	2	1.50		
	Less competent	2	4	3	1	10	7.52		
	Competent	22	14	6	4	46	34.59		
	Very competent	26	30	16	3	75	56.39		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**3.46**	**.702**
DVDS	Not competent	2	0	0	1	3	2.26		
	Less competent	1	5	2	0	8	6.02		
	Competent	14	9	8	2	33	24.81		
	Very competent	34	34	16	5	89	66.92		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**3.56**	**.711**
Power point	Not competent	0	2	1	0	6	35.34		
	Less competent	5	6	4	1	16	2.26		
	Competent	22	17	4	4	47	12.03		
	Very competent	24	23	17	3	67	50.38		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**3.34**	**.777**
Youtube	Not competent	0	1	0	0	1	0.75		
	Less competent	2	2	2	2	8	6.02		
	Competent	25	13	7	2	47	35.34		
	Very competent	24	32	17	4	67	57.89		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**3.50**	**.647**
Animations	Not competent	1	1	1	1	4	3.01		
	Less competent	24	15	5	1	45	33.83		
	Competent	16	23	12	6	57	42.86		
	Very competent	10	9	8	0	27	20.30		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**2.80**	**.793**
Captions	Not competent	2	3	0	1	6	4.51		
	Less competent	31	26	15	6	78	58.65		
	Competent	12	12	8	1	33	24.81		
	Very competent	6	7	3	0	16	12.03		
	Total	**51**	**48**	**26**	**8**	**133**	**100**	**2.44**	**.763**

From analysis in Table 4.8 it can be observed that majority of teachers (66.92%) are very competent in use of DVDs while 57.89% are very competent in Youtube while 56.39% were very competent in CDs. This indicates that majority of teachers who could be using the listed ICT resources may have been using DVDs, Youtube and CDs in biology teaching in public secondary schools in Kiambu County. The study also revealed that only 20.30 % of sampled

teachers were very competent in animations and 12.03% agreed that they were very competent in captions. Comparatively, both captions and animations recorded the highest less competent of 33.83% and 58.65% respectively. On average it seems most teachers of biology are competent using DVDs, Youtube, CDs and Powerpoints. 58.65% of teachers were less competent in captions and 33.83% were less competent in animations. This indicates that animations and captions had the most less competency. Powerpoint had the least less competent of 2.26%. This means that majority of teaches of biology can comfortably use the Youtube to teach biology. DVDs had majority of very competent teachers 57.62% followed by CDs 50.98% while Powerpoint and Youtube had 47.05% each.

The researcher also went ahead and compared the ICT resources competency with age and realized that; CDs had 47.82% competent teachers were 20-30 years of age and 30.43% were 31-40 years of age. 10% of teachers of biology who were competent were 51-60 years. 34.66% of very competent were below 30 years while 40% were 31-40 years and 04% were 51-60 years.

4.4.1.4 Teachers of biology competency in use of ICT

The teacher of biology competence was of importance to the study and therefore, it was investigated. The information obtained is presented in Table 4.9.

Table 4.9

Teachers of Biology Competency in Use of ICT

	Strongly disagree		Disagree		Agree		Strongly agree			
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Mean	Std. Deviation
I feel confident working on a computer	5	3.8%	5	3.8%	31	23.3%	92	69.2%	3.58	.741
I feel confident installing software	11	8.3%	19	14.3%	84	63.2%	19	14.3%	2.83	.770
I feel confident organizing and managing files	8	6.0%	16	12.0%	76	57.1%	33	24.8%	3.01	.783
I feel confident learning about computer hardware	14	10.5%	0	0.0%	19	14.3%	100	75.2%	4.17	1.304
I feel confident learning about computer software	4	3.0%	22	16.5%	72	54.1%	35	26.3%	3.04	.743
I feel confident learning advanced skills of using computer programs	5	3.8%	50	37.6%	48	36.1%	30	22.6%	2.77	.840
I feel confident getting help on problems related to computers	23	17.3%	46	34.6%	60	45.1%	4	3.0%	2.34	.797
I feel confident surfing the internet	2	1.5%	8	6.0%	69	51.9%	54	40.6%	3.32	.656
I feel confident integrating ICT in instruction	4	3.0%	5	3.8%	70	52.6%	54	40.6%	3.31	.687
I feel confident developing simple programs for the computers	39	29.3%	22	16.5%	43	32.3%	29	21.8%	2.47	1.132

Analysis in Table 4.9 shows that some statements got very high rankings. These are: I feel confident learning about computer hardware (75%) I feel confident working on a computer (69.2%). Other statements got an average ranking such as I feel confident surfing internet (40.6%) and I feel confident integrating ICT in instructions (40.6%). Some statements rankings were below average such as I feel confident organizing and managing files (24.8%) and I feel confident learning about computer software (26.3%). From the data, the teachers sampled were not confident getting help on problems related to computers (3.0%). From the data gathered, It is also worth noting that the statements skewed towards integrating ICT in instruction received a lower rating and the implication is that most of the teachers in the sampled schools may have

had a challenge in integrating ICT in biology teaching. A study by Mutwiri et al. (2021) supports this by observing that ICT competency toward ICT integration have been theorized to be a determining factor on how well a teacher is able to effectively use technology to improve teaching.

4.4.1.5 Frequency of Using Computers to Execute Various Tasks by the Teacher of Biology

The researcher sought data on the frequency of execution of various tasks by the teachers of biology in the sampled public secondary schools. This is in a way to show competence of the teachers of biology. The data obtained is presented in Table 4.10.

Table 4.10

Frequency of Using Computers to Execute Various Tasks by The Teacher of Biology.

	Never		Rarely		Occasionally		Everyday			
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Mean	Std. Deviation
Typing work	0	0.00%	30	22.56%	88	66.17%	15	11.28%	1.89	.573
Keeping records	3	2.26%	18	13.53%	95	71.43%	17	12.78%	1.95	.594
Games	35	26.32%	56	42.11%	36	27.07%	6	4.51%	1.10	.843
Communication	6	4.51%	18	13.53%	31	23.31%	78	58.65%	2.36	.882
Teaching	2	1.50%	10	7.52%	102	76.69%	19	14.29%	2.04	.528

The results in Table 4.10 show frequency of using computers to execute various tasks by the teacher of biology in public secondary schools in Kiambu county. From the analysis it can be observed that majority (58.65%) of teachers use computers every day for communication purposes . Using computers every day for typing, keeping records, games and teaching received a very low ranking of 11.28%,12.78%, 4.51% and 14.29% respectively. This shows that the teachers of biology did not integrate computers well since their ranking for using the computers everyday has received poor ranking. However, it is worth noting that all teachers sampled had used computers for typing at one time in their profession. 26.32% had never used computers for games at all while only 1.50% had never used computers for teaching. The proportion is insignificant and researcher cannot conclude that teachers were not integrating ICTs. From the data obtained, it is also easy to see that many teachers (41.35%) were not using ICT for daily communication and perhaps collaborating with peers in the rest of the world. As a result, and as expected, they were unable to participate effectively in the global information society. The current findings are consistent with those of the study done by Ampofo et al. (2020) on the use of ICT among secondary school teachers in Nigeria which found that most teachers had access

to computers but lacked e-mail. Therefore, though ICTs are meant to avail to teachers the tools needed for the information or knowledge (Omariba et al. 2016).

A study by Mogeni (2020) revealed that the highest percentage of use of ICTs by teachers was for communication purposes. As can be gauged from the above-mentioned studies teachers use the ICTs applications mainly for communication purposes.

4.4.1.6 Level of Expertise in Computer Use by Teachers of Biology

The researcher investigated the ability of the teachers of biology to carry out certain functions using computers in biology teaching. The functions were from the simplest to more complicated. The level of expertise was to help the researcher gauge the competence of the teachers of biology. Responses given by the teachers of biology in the sampled public secondary schools were recorded in Table 4.11.

Table 4.11

Level of Expertise in Computer Use by Teachers of Biology

	Strongly disagree		Disagree		Agree		Strongly agree			
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Mean	Std. Deviation
Able to carry out computer booting functions	7	5.26%	8	6.02%	34	25.56%	84	63.16%	3.47	.831
Able to carry out basic computer functions	3	2.26%	2	1.50%	39	29.32%	89	66.92%	3.61	.638
Able to use word processor and spreadsheet for teaching in a biology lesson	1	0.75%	14	10.53%	27	20.30%	91	68.42%	3.56	.711
Able to use internet and open sourcing for teaching biology	2	1.50%	3	2.26%	33	24.81%	95	71.43%	3.66	.602
Able to comfortably use e-mails for communication	3	2.26%	6	4.51%	27	20.30%	97	72.93%	3.64	.678

The results in Table 4.11, show the level of expertise in use of ICT by teachers of biology in sampled public secondary schools in Kiambu County, Kenya. From the analysis, it can be observed that 11.46% of sampled teachers strongly disagreed and disagreed that they could be able to boot a computer. This means that 88.54% of the sampled teachers of biology could boot a computer in readiness for use. 66.92% of the respondents strongly agreed that they were able to carry out the basic computer functions. The basic computer functions would include opening

a word document, opening a spreadsheet such as Ms. excel, opening PowerPoint and shutting down a computer. This kind of response was very impressive. This is a positive indicator of integration of ICT in biology teaching. 88.72%of the respondents either agreed or strongly agreed that they could be able to use word processor and spreadsheet for teaching in a biology lesson. This proportion was also very impressive since only a handful of teachers could not be able to use the spreadsheet and word processor. Word processor and spreadsheet have myriad of uses in teaching and it is therefore an indication of teachers who are ready to integrate the ICT. The researcher also looked at the teachers of biology ability to use internet and Open Education Resources (OER) for teaching biology.

The results showed that 94.24% of the sampled teachers of biology agreed or strongly agreed that they were able. This was also impressive since internet has a huge potential in giving resources required for biology teaching such as images and video. This is therefore an excellent sign of teachers who are ready to integrate ICT in biology teaching in public secondary schools. Lastly the researcher investigated the proportion of teachers of biology who were able to comfortably use e-mails for communication. The response of this item was also very impressive since 93.23% agreed or strongly agreed that they were able to comfortably use e-mails for communication This means they would receive, read and reply email communications. From the Table 4.12, it can be concluded that a majority of the teachers have the level of expertise required to integrate ICT in biology teaching in public secondary schools in Kiambu County.

4.4.1.7 Teachers of Biology Stages of Integrating ICT

Various teachers of biology could be at different stages of integration of ICT in their teaching. The current study went further and investigated the stages of integration of ICT where the sampled teachers of biology were. The information obtained is presented in the Table 4.12.

Table 4.12

Stages of Integration of ICT by Teachers of Biology

	Would like assistance		Somewhat comfortable		Very comfortable			
	Count	Row N %	Count	Row N %	Count	Row N %	Mean	Std. Deviation
Awareness: I am aware that ICT exist but have not used it	12	9.02%	31	23.31%	90	67.67%	2.59	.653
Learning: I am learning basics, though I have no confidence using ICT	14	10.53%	33	24.81%	86	64.66%	2.54	.680
Understanding: I do understand the process of using ICT in teaching	8	6.02%	26	19.55%	99	74.44%	2.68	.582
Familiarity: I am gaining a sense of self-confidence in using the computer for teaching	4	3.01%	34	25.56%	95	71.43%	2.68	.528
Adaptation: I think about computer as an instructional tool and I can use many different computer applications for teaching biology	19	14.29%	22	16.54%	92	69.17%	2.55	.733
Creative application: I can apply what I know about technology in class and am able to use it as an instructional aid and have fully integrated computers into the curriculum	11	8.27%	91	68.42%	31	23.31%	2.15	.544

The results in Table 4.12 show various stages of ICT integration that the sampled teachers of biology are in. From the analysis, it can be observed that 67.67% were aware that ICT existed since they were very comfortable. 9.02% were not comfortable with the stage of awareness. This implies that majority of teachers were past the stage of awareness. On the stage of learning, 64.66% were very comfortable and 10.53% were not comfortable. This indicates that majority of teachers were past the stage of learning about ICT integration. The third stage was understanding where 74.44% were very comfortable while only 6.02% were uncomfortable. This means majority of the sampled teachers had gone past understanding stage. The fourth stage was familiarity and the 71.43% of the sampled teachers were very comfortable while only a staggering 03.01% conceded that they were uncomfortable with this stage. The fifth stage is adaptation where only 69.17% of the sampled teachers were comfortable and 14.29% were uncomfortable. The last stage was creative application of ICT. This stage had only 23.31% being comfortable and this is an indication that majority of sampled teachers of biology were not applying the ICT creatively during biology teaching. The findings are supported by Karunakaran and Dhanawardana (2023) in their study who found that teachers are in different levels of integration of ICT. It is also supported by Sawyerr and Agyei. (2023) in their study

on integration of ICT in mathematics teaching in Ghanaian schools who found that majority of teachers are at lower level of integration of ICT.

4.4.1.8 Importance of Computer Skills in the Life of a Teacher of Biology

The researcher investigated the teachers of biology feelings about the essentiality of a computing skills to their lives. The responses given are presented in the Table 4.13.

Table 4.13

Computer Skills are Essential in the Life of a Teacher

	Strongly disagree		Disagree		Agree		Strongly agree	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Computer skills are essential in the life of a teacher	2	1.50%	2	1.50%	21	15.79%	108	81.20%

The results in Table 4.13 Show the feelings of teachers of biology in terms of importance of computer skills in their lives in public secondary schools in Kiambu county. From the analysis, it can be observed that 81.20% strongly agree that the skills are essential in the life of a teacher. 15.79% indicated agreed. The total number of those who agreed or strongly agree was impressive 96.99%. this is a group of teachers who have a prospect of integrating ICT in their teaching. An insignificant percentage 1.5% strongly agreed while a similar percentage just disagreed that computer skills are essential to the life of a teacher. Having 81.2% strongly agreeing signifies an overall positive attitude by teachers of biology towards the use of ICT.

According to Tzafilkou et al. (2023), teachers should see the need to question or change their professional practice if they are likely to adopt the use of ICTs. Perceived usefulness of ICTs to them, and the instructional process makes them more likely to have a positive attitude toward the use of ICTs in the classroom. Perceived ease of use of the ICTs at a personal level as well as for teaching in the classroom will also influence their attitude. Mensah et al. (2023) observes that the more positive the responses to the factors of perceived usefulness and perceived ease of use, then the more positive the attitude of teachers will be to the use of ICTs and the more likely they will be to use ICTs in their teaching.

4.4.1.9 Use of Personal Computers by Teachers of Biology

The researcher was also interested with information on use of personal computers by the teachers of biology. This is because the use of a personal computer is an important indicator of the level of confidence, value placed on the functionality of computers by the teacher and apparently the competence of the teacher. Information obtained is presented in Table 4. 14.

Table 4.14

Use of Personal Computer in Biology Teaching

		How often do you use personal computer in teaching Biology					Total (%)
		Not at all (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)	
School category	Sub-county	5 (6.8)	16 (21.6)	39 (52.7)	12 (16.2)	2 (2.7)	74 (100.0)
	County	2 (6.7)	3 (10.0)	18 (60.0)	5 (16.7)	2 (6.7)	30 (100.0)
	Extra county	2 (8.3)	1 (4.2)	18 (75.0)	3 (12.5)	0 (0.0)	24 (100.0)
	National	1 (20.0)	0 (0.0)	2 (40.0)	1 (20.0)	1 (20.0)	5 (100.0)
Total		**10 (7.5)**	**20 (15.0)**	**77 (57.9)**	**21 (15.8)**	**5 (3.8)**	**133 (100.0)**

The results in Table 4.14 Show the use of personal computers in biology teaching among the sampled teachers in public secondary schools in Kiambu County, Kenya. From the analysis, it can be observed that teachers who didn't at all was 7.5 % (n=10), rarely 15.0 % (n=20), sometimes 57.9 % (n=77), often 15.8 % (n=21), and always 3.8 % (n=5). A study by Mogeni (2020) support the findings and concludes that teachers who use personal computers are more likely to integrated ICTs in their teaching. A study by Sanni and Bolaji (2024) shows that the teachers with personal computers are likely to integrate ICT more in their teaching endeavor. Their study concludes that having a personal computer by the teacher is a key contributing factor to competence of teacher in use of ICT. Altan et al. (2024) in their study on post pandemic integration of ICT, concludes that teachers computer competence is achieve through regular use and practice and hence teachers with personal computer end up being more competent in their use and apparently achieve more in terms of integration in teaching.

4.4.2 Descriptive Statistics on Availability of ICTs in Sampled Public Secondary Schools

Table 4.15

The Distribution of the Descriptive Statistics on *Availability of ICT Resources in the Sampled Schools*

		Not available at all	Inadequate	Fairly adequate	Adequate	Total	Mean	Std. Deviation
Availability of computers	Sub-county	0	14	30	30	74		
	County	0	6	12	12	30		
	Extra county	0	4	15	5	24		
	National	0	0	1	4	5		
Total		**0**	**24**	**58**	**51**	**133**	**2.20**	**0.726**
Availability internet	Sub-county	8	3	30	33	74		
	County	0	4	9	17	30		
	Extra county	0	6	14	4	24		
	National	0	1	1	3	5		
Total		**8**	**14**	**54**	**57**	**133**	**2.20**	**0.860**
Availability of digital cameras	Sub-county	17	47	5	5	74		
	County	9	19	1	1	30		
	Extra county	7	10	3	4	24		
	National	0	0	1	4	5		
Total		**33**	**76**	**10**	**14**	**133**	**1.04**	**0.865**
Availability of projectors	Sub-county	3	33	8	30	74		
	County	1	3	9	17	30		
	Extra county	2	3	7	12	24		
	National	0	3	2	0	5		
Total		**6**	**42**	**26**	**59**	**133**	**2.04**	**0.972**
Availability interactive whiteboard	Sub-county	46	10	2	16	74		
	County	19	0	3	8	30		
	Extra county	13	2	3	6	24		
	National	1	1	2	1	5		
Total		**79**	**13**	**10**	**31**	**133**	**0.95**	**1.269**
Availability of a computer laboratory	Sub-county	34	20	8	12	74		
	County	1	8	16	5	30		
	Extra county	3	12	8	1	24		
	National	1	1	1	2	5		
Total		**39**	**41**	**33**	**20**	**133**	**1.26**	**1.042**
Availability of video conferencing equipments	Sub-county	44	18	9	3	74		
	County	25	4	1	0	30		
	Extra county	18	3	1	2	24		
	National	1	0	0	4	5		
Total		**88**	**25**	**11**	**9**	**133**	**0.56**	**0.908**

From analysis in Table 4.15, it can be observed that national public secondary schools have a larger majority (75%) of the respondent teachers who stated that computers were available and only 25% stated that they were fairly adequate. However, in extra-county schools, majority of teachers of biology felt that the computers were fairly adequate 62.5% while 20.9% felt that they were adequate and 16.6% were for the idea that they were inadequate. All the sampled extra-county schools had computers. The situation in sub-county schools was that 19% had inadequate computers while 40.5% had fairly adequate and another 40.5% had adequate computers. In summation it was found that all public secondary school sampled in Kiambu County had computers for use in biology teaching. From the questionnaires, no particular respondent said their school had no computer at all. This confirms the notion that Kiambu County is well endowed with resources and all public secondary schools have installed computers which may favour the integration of ICT in biology teaching.

A study by Song et al. (2021) concludes that the availability of computers affects the level and process of ICT integration in teaching. Another study Saber (2021) indicate that lack of computers is a major barrier to the integration of technology by teachers. These findings also concur with Ntorukiri et al. (2021) findings that 87% of secondary schools in Meru had computers and Wanga (2014) who found that 91% of public secondary schools in Gilgil Sub-County had computers. Respondents agreed with a mean of 2.20 and a standard deviation of 0.726 that the computers available in their schools were fairly adequate. The current study has also found that 100% of the schools had computers at their disposal for use by the teachers of biology. The current study was taken in the year 2023 and considering the price of computers has drastically reduced in recent past years and hence acquisition of the same have become relatively easier.

Considering the numerous benefits that internet has and its impact on teaching, the researcher found it important to assess its availability in the sampled public secondary schools. It was found that availability of internet in the sampled schools was fairly adequate. This is confirmed by a mean of 2.20 and a standard deviation of 0.860. Internet is a powerful resource when availed for use Mogeni (2020) in support argue that by connecting computers to the internet in schools, the computers are transformed into powerful communication devices with countless teaching applications. There is need therefore for schools to invest in the installation of internet. Schools' administrations need to be sensitized of the subsiding costs of internet connectivity for teaching and the enormous benefits offered by such connection.

Internet is an essential resource for biology teaching. It can be used to download teaching materials such as images of organisms not found within Kiambu County and videos to facilitate productive interactions, finding new sources of knowledge, extending classroom interactions, doing research, sourcing for biology projects, and collaborative learning in biology. The schools in the County had a fairly available internet for use by the teachers of biology. These findings were not in agreement with those of Kirimi (2014) who found that Majority (72%) of secondary schools in Murang'a had no internet connection in their schools. And only 28% of schools had internet connections. Owiti (2019) did a study on use of ICT in teaching and learning of secondary schools biology in Migori county, Kenya and found out that three quarters (75%) of the secondary schools had no internet connectivity which is necessary for information and data retrieval (Owiti, 2019) which implied that teachers were unable to access various sources of information which they could present to the learners during the actual teaching for better results in terms of students' performance. According to Kunda et al. (2018), internet use enhances collaborative development of skills and abilities to create knowledge among the learners. Efficient use of the internet brings a better preparation for the students, lifelong learning and better opportunity to join the job industry. Owiti posits that the aim of integrating ICT in instruction mainly should be as a teaching aid for existing subjects. Use of ICT therefore in biology instruction can bring about improvement in learners' performance.

In support of this, Mutai et al. (2020) notes that ICT integration enables students to transfer gained experiences to real life situations and daily applications. Moreover, learners would be able to use ICTs responsibly and effectively if they are exposed to relevant experiences during learning. Maupa, and Goronga (2023) notes that, use of the internet improves the quality of learning that will translate in high achievement. This view is supported by Daniel and Khaemba (2021) who argues that the internet offers opportunities for active and collaborative learning with the other related benefits. The benefits include but not limited to; an environment that is inviting and well-organized, learning activities that are student-centered and adapted to learning needs and preferences, monitoring of students' progress through multiple pathways, supporting the teaching and learning environment for technology and instruction work together in support of the teachers and students.

The study also differs with another one done by Minae (2014) on access and pedagogical integration of information and communication technology in secondary schools in Nairobi and Kiambu Counties which found that only 39.2% of the schools were connected to the internet. The disparity in the finding may have been brought by the availability of cheap internet

connections from the Internet Service Providers (ISP) in last recent past. In the same line, today one can use a modem or a smart phone to provide internet to the computer also called hotspot. The price and time could be two major contributing factors to the increased internet connectivity in the schools in Kiambu County. In addition, Kiambu County is better endowed in terms of resources than majority of rural designated Counties. Some schools therefore in the study are those that miss out on the numerous benefits of the use of internet in teaching and learning. Another ICT resource that the researcher was interested in was the projector. There are four different types of projectors in Kenyan market today. These are Liquid Crystal Display (LCD), Light Emitting Diode (LED), Digital Light Processing (DLP) and Liquid Crystal On Silicon (LCOS). The researcher was not interested with the type of the projector but its availability for use by the teachers of biology.

A projector can be used by a teacher of biology to increase students' engagement by allowing them to collectively participate in presentations such as video, games, content and other group activities all in one session. In addition, a teacher can access different elements of a lesson such as a lesson plan and lesson notes by just plugging a USB directly into the projector. In a summation, projectors provide a big screen for view by the learners Owiti (2019). The data gathered shows that projectors were available and fairly adequate. This was shown by a mean of 2.04 and a standard deviation of 0.972. Public secondary schools in Kiambu therefore have projector required for teaching. Interactive white board (IWB) is also known as smart or living board. Sun et al. (2022) defines it as a large, touch-sensitive board, which is connected to a digital projector and a computer. The projector displays the image from the computer screen on the board. The computer can then be controlled by touching the board, either directly or with a special pen. Unlike any other teaching tools, Interactive Whiteboard is definitely the most interactive tool ever used in the classrooms for teaching. Compared to ordinary PowerPoint presentation slides, teachers and student are given the chance to interact during the lesson. The teachers can always invite their students to the front and ask them to write or draw on the board, drag and drop words or images into specific locations on the board and numerous more activities.

The ability of the tool to sense touch and different colours input makes it attractive, easy and effective for the students to use and experience. In an Interactive Whiteboard study by Krithika and Devi (2023). The findings suggest that the board makes a difference to aspects of classroom interaction where there are more interactions between teachers and students in the IWB lessons compared to the non-Interactive whiteboard lessons. A research study by Sun et al.

(2022) indicated a result that the usage of Interactive Whiteboard has risen student achievement by 16 percent. IWB is therefore an essential ICT tool to be integrated in biology lessons. From the current study, 60% of the sampled schools had not installed IWB while 10% were inadequate, 7.5 were fairly adequate and only 22% had adequate. This means that 88% of all public secondary schools in Kiambu County may miss the benefits brought by use of IWB in education since they did not have adequate IWB in the school. This is therefore a research gap where one can look at the influence of IWB to teaching in the county.

Digital camera is an electronic device which produces digital images that can be stored in a computer and displayed on screen. The researcher investigated adequacy of digital cameras for use in biology teaching in public secondary schools in Kiambu County. The data obtained depicts that, 25% of the schools sampled had no digital cameras at all, 57% had digital cameras but they were inadequate, 7.5% were fairly adequate and only 10% had adequate digital camera tools. This means that only 10% has an opportunity to exploit the benefits of the digital cameras in education while 90% will miss out. According to Krithika and Devi (2023), the benefits of digital cameras include instantaneous satisfaction, film produced is inexpensive, they have massive storage space for photos, they have multiple functions, images are easy to share, they are smaller and lighter, images are easy to edit, they have more display options, images can be printed from home or office, point and shoot technology is applied and lastly, they have a quicker operation than analogue cameras. The researcher identifies a research gap by the fact that only 10% have the digital cameras available adequately for use in biology teaching. Al Husaeni et al. (2024) did a study whose results indicated that the digital camera did increase student learning of process skills in the two biology laboratory activities. The results of unpaired "t" tests for independent data indicated the differences were statistically significant for the process questions, while the differences in responses to the content questions were not significantly different. Anecdotal evidence also indicated that the experimental group took more interest in setting up the apparatus and made fewer mistakes in the lab procedure than did the control group.

The researcher also did a study on availability of computer laboratories in the sampled schools. From the study, majority of the respondents said that computer laboratory were inadequate in their schools as shown by a mean of 0.81 to 1.060 this could adversely affect teaching. In support of this, Ismail et al. (2020) in their study notes that lack or inadequate ICT resources can seriously limit what the teachers can do in the classroom using computers. The results of this study confirm an earlier study done by Fomunyam (2019). on technological availability in

schools in African. He affirmed that, African countries have insufficient numbers of ICT resources and other related ICTs related resources and therefore limited use in the classroom. The results are also in congruence with the findings by Miima (2014) who found that secondary schools in Kakamega had no adequate ICT tools necessary for integration of ICT and this affected the integration of ICT in teaching Kiswahili. The researcher investigated availability of video conferencing equipment in the sampled schools. According to Torrato et al. (2021), Video conferencing is connecting individuals and groups via telecommunication networks and video technologies in real time. The sound and images are transmitted electronically in a digital format, which provides simultaneous interactive communication. The data obtained from the current study shows that 66% of the schools did not had video conferencing equipments while 19% were inadequate, 8% were fairly adequate and only 7% had adequate. The study has shown inadequacy of video conferencing equipments. Several studies conducted have shown the benefits of using video conferencing to teach. One of such studies is by Paderanga (2014) who states that video conferencing services tend to offer more than just face-to-face interactions. He notes that video conferencing services let users share their screens, remotely access one another's desktops, chat via text, exchange files, communicate via digital whiteboards, and even broadcast conferences to large groups of passive viewers.

In support, Torrato et al. (2021) did a study in Philippines and concludes that video conferencing (VC) has become an essential component in the world of education and many other fields. The study concludes that this method has given schools new ways of presenting materials, working with teachers and students; thus, stimulates the development of strategies that are consistent with new technology. From the current studies, it is evident that only 7% of schools are able to reap full benefits of video conferencing in biology teaching the learners. 93% of the schools have no video conferencing and therefore disadvantageous to a significant number of learners in Kiambu County. This seems to be the most inadequate ICT resource among those listed and investigated. It is evident that public secondary schools in Kiambu County had inadequate ICT such as digital cameras, projectors, interactive whiteboard, computer laboratory, and video conferencing equipment which could be posing a big challenge in integration of ICT in biology teaching in public secondary schools. This a rich area for future research and a gap has been identified. Therefore, the teachers' most preferred ICT resources (or hardware) were desktop computers, while their most preferred ICT application (or software) was word processing using Microsoft Word.

4.4.2.1. Descriptive Statistics of Access of ICT Resources in the Computer Laboratory by Teachers of Biology

The researcher collected and analysed data how frequent the sampled teachers of biology accessed ICT resources in the computer laboratories. The researcher noted that despite having ICT resources in the schools sampled, it was necessary to find out from the teachers of biology how often they accessed them. The data collected has been presented in Table 4.16.

Table 4.16

Descriptive Statistics on Access of ICT Resources in Computer Laboratory

		How often do you access ICT resources in computer lab				
		Not at all (%)	Rarely (%)	Sometimes (%)	Often (%)	Total (%)
School category	Sub-county	28 (37.8)	12 (16.2)	25 (33.8)	9 (12.2)	74 (100.0)
	County	4 (13.3)	6 (20.0)	18 (60.0)	2 (6.7)	30 (100.0)
	Extra county	1 (4.2)	16 (66.7)	6 (25.0)	1 (4.2)	24 (100.0)
	National	0 (0.0)	0 (0.0)	3 (60.0)	2 (40.0)	5 (100.0)
Total		**33 (24.8)**	**34 (25.6)**	**52 (39.1)**	**14 (10.5)**	**133 (100.0)**

From analysis in Table 4.16 shows that teachers of biology access of ICT resources in computer laboratory as follows; not at all 24.8 % (n=33), rarely 25.6 % (n=34), sometimes 39.1 % (n=52), and often 10.5 % (n=14). From the table 4.6, 24.8% had not accessed the ICT resources in the computer laboratory at all and therefore most probably they had not integrated the ICT in their teaching. Quarter of the teachers of biology sampled rarely accessed the ICT in the computer laboratory while 39.1% only accessed the ICT resources sometimes. A small portion of teachers of biology 10.5% accessed the ICT resources quite often. This is the group of teachers that most probably integrated the ICT in biology teaching in public secondary schools in Kiambu County. Minae (2014) noted that mere presence of ICT instructional resources in schools does not guarantee their access and utilization. Owiti (2019) in her study done in Migori County observed that 72% of ICT resources used by secondary school teachers were accessed from computer laboratory. She therefore concludes that computer laboratories are the serving points of ICT resources in a school.

According to Minae (2014), this status falls short of the constructivist's requirements for ICT integration requirements that each and every teacher in school should have access ICT resources often. With this status in access, teachers in these public secondary schools are not going to benefit from many advantages presented by ICT integration in education.

Consequently, they will continue to miss out on educational solutions offered by ICT, which limits their chances of tapping from the ICTs and ultimately from improving the quality of their teaching.

4.4.2.2 Descriptive Statistics on Software Applications Used by teachers of Biology in Sampled Secondary Schools.

Apart from hardware, the type and variety of software applications available in a school is also an important indicator of the capacity of an institution to support meaningful ICT integration (Minae 2014). Through review of literature, the researcher found it necessary to assess the types of softwares that were available in public secondary schools in Kiambu County. The researcher enlisted the commonly used softwares used by teachers of biology and sought data on their availability for use by the teachers of biology. The researcher had given options of Ms word, Ms excel, Ms PowerPoint, crocodile biology and pro-biology. The data obtained is presented in the Table 4.17.

Table 4.17

Descriptive Statistics on Types of Software Available for use by the Teachers of Biology

	Not available		Inadequate		Fairly available		Adequate			
		Row N		Row N		Row N		Row N		Std.
	Count	%	Count	%	Count	%	Count	%	Mean	Deviation
Availability of Ms word	6	4.51%	17	12.78%	16	12.03%	94	70.68%	2.49	.884
Availability of Ms excel	4	3.01%	20	15.04%	16	12.03%	93	69.92%	2.49	.858
Availability of Ms powerpoint	7	5.26%	22	16.54%	24	18.05%	80	60.15%	2.33	.935
Availability of Crocodile biology	48	36.09%	65	48.87%	15	11.28%	5	3.76%	.83	.774
Availability of pro biology	87	65.41%	33	24.81%	8	6.02%	4	3.01%	.49	.804

From analysis in Table 4.17, it is observed that the types of software applications that are available in schools are predominantly “office software” or “productivity tools” such as word processing software (Ms word), spreadsheets and database management applications (Ms excel). 70.68% of the respondents stated that Ms word was adequate. Ms. Excel was available as stated by 69.92% while Ms. Powerpoint was adequate as stated by 60.15%. There is relatively less variety in the available software especially the ones that are used for pedagogical practice (e.g., simulations, drill and practice, tutorials). This is clearly indicated by the fact that only 3.76% of teachers interacted or used crocodile biology while a lesser percentage 3.01%

used pro-biology. The findings are consistent with a study by Mogeni (2021) who found that most schools only have productive softwares and lack specialized softwares for the subjects. Another study by Owiti (2019) revealed that schools are reluctant to acquire the specialized softwares for their subjects.

4.4.3 Descriptive Statistics on Challenges Facing Integration of ICT in Biology Teaching

The researcher sought data pertaining challenges facing teachers of biology in the process of integration of ICT in biology teaching. The responses given are presented in Table 4.18.

Table 4.18

Descriptive Statistics on Challenges That Affect the Integration of ICT in Biology Teaching in the Sampled Public Secondary Schools

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %
Lack of adequate ICT skills	3	2.26%	12	9.02%	39	29.32%	79	59.40%	0	0.00%
Lack of motivation to use ICT	1	0.75%	23	17.29%	71	53.38%	38	28.57%	0	0.00%
Inadequate power supply	10	7.52%	54	40.60%	54	40.60%	15	11.28%	0	0.00%
Limited time to access the lab	6	4.51%	22	16.54%	83	62.41%	22	16.54%	0	0.00%
Inadequate infrastructure	2	1.50%	14	10.53%	69	51.88%	48	36.09%	0	0.00%
Bureaucracy in getting access	2	1.50%	25	18.80%	76	57.14%	30	22.56%	0	0.00%
Limited ICT facilities	4	3.01%	12	9.02%	78	58.65%	39	29.32%	0	0.00%
Inadequate internet services	5	3.76%	22	16.54%	66	49.62%	40	30.08%	0	0.00%
Lack of hands on experience	2	1.50%	51	38.35%	70	52.63%	10	7.52%	0	0.00%
Management of the lab equipment's	3	2.26%	72	54.14%	44	33.08%	14	10.53%	0	0.00%
Lack of ICT policy	3	2.26%	81	60.90%	33	24.81%	16	12.03%	0	0.00%

From analysis in Table 4.18 it can be observed that, none of the respondents (0.00%) strongly agreed that the identified challenges existed in their schools. A few teachers of biology agreed that some of the challenges were experienced in their schools. The largest number of teachers

of biology that agreed were for the lack of ICT skills as a challenge that affects the schools sampled. This formed 59.40% and this was the only challenge that had over 50% of sampled teachers agree. 36.09% agreed that their schools were faced by a challenge of inadequate ICT facilities. This seems a small percentage as the large majority of teachers did not see it as a challenge. 30.08% agree with the fact that inadequate internet services was a challenge. The rest of the challenges had below 30% of the respondents agreeing that it exist. Of all the challenges enlisted, lack of hands-on activities had the list agreed with only 07.52% which show that the teachers sampled believed they had the required hands -on experience to enable them integrate ICT in biology teaching.

4.4.4 The Descriptive Statistics on Principals Role in Integration of ICT

Principal is a title given to a qualified person heading a public secondary school in Kenya. Some principals have a higher grade and are designated as senior principal or chief principal such as those heading extra-County or National public secondary schools. Principals are the instructional heads in their schools. In their capacity they play an important role in leading ICT integration into teaching (Mogeni et al, 2021), because they can foster the use of ICT at a strategic and action level (Mutai et al, 2020). The principals support includes supervision of teachers, training of teachers more, training more teachers, observing teachers in class, providing enough ICT resources and maintaining the ICT resources in the school. Mutisya (2014) postulates that if the principals plan their roles effectively, the integration of ICT by teachers can be seen at a significant level. Muthoni (2017) concluded that with principals' effort, ICTs can be integrated into old and new methods of teaching in a school setting. From these studies, it is possible to conclude that the principal has an opportunity to guide teachers in integration of ICTs into teaching process

The current study sought data on principal's view on various aspects that can affect integration of ICT in biology teaching. The results are results obtained have been presented in Table 4.19

Table 4.19

Descriptive statistics* on *Principals' Role in the Integration of ICT in Biology Teaching

		School category (%)				
		Sub-county	County	Extra county	National	Total
How can principals improve ICT integration in Biology teaching?	Train more teachers, buy more computers, and train teachers more	5 (7)	5 (29)	1 (17)	2 (100)	13 (14)
	Train more teachers, buy more computers, train teachers more, and strict supervision of teachers	55 (81)	10 (59)	5 (83)	0 (0)	70 (75)
	Train more teachers, buy more computers, train teachers more, strict supervision of teachers, and providing internet	8 (12)	2 (12)	0 (0)	0 (0)	10 (11)
How often do you visit to observe teachers of Biology while teaching in their respective classes?	Rarely	1 (1)	1 (6)	0 (0)	0 (0)	2 (2)
	Sometimes	23 (34)	0 (0)	0 (0)	0 (0)	23 (25)
	Often	44 (65)	16 (94)	6 (100)	2 (100)	68 (73)
How often do you delegate to HODs the supervision/ observation of teachers of Biology?	Rarely	62 (91)	14 (82)	5 (83)	2 (100)	83 (89)
	Sometimes	5 (7)	3 (18)	1 (17)	0 (0)	9 (10)
	Often	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)
To what extent does the principals' supervision influence integration of ICT in Biology teaching?	Large extent	63 (93)	14 (82)	5 (83)	2 (100)	84 (90)
	Very large extent	5 (7)	3 (18)	1 (17)	0 (0)	9 (10)
How many computers do you have in your school?	1-5	33 (49)	3 (18)	2 (33)	1 (50)	39 (42)
	6-10	25 (37)	9 (53)	3 (50)	0 (0)	37 (40)
	11-15	7 (10)	4 (24)	1 (17)	0 (0)	12 (13)
	16-20	1 (1)	1 (6)	0 (0)	0 (0)	2 (2)
	Over 20	2 (3)	0 (0)	0 (0)	1 (50)	3 (3)
How often do you service ICT resources in your school?	Never	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)
	Rarely	25 (37)	2 (12)	1 (17)	1 (50)	29 (31)
	Sometimes	30 (44)	12 (71)	4 (67)	1 (50)	47 (51)
	Often	10 (15)	1 (6)	1 (17)	0 (0)	12 (13)
	Always	2 (3)	2 (12)	0 (0)	0 (0)	4 (4)
How enough is the budgetary allocation for ICT repairs in your school?	Not enough	65 (96)	14 (82)	5 (83)	2 (100)	86 (92)
	Enough	2 (3)	3 (18)	1 (17)	0 (0)	6 (6)
	Very enough	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)
In your own opinion, do you think maintenance of ICT has an influence to the integration of ICT in biology teaching in secondary schools?	Strongly Disagree	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)
	Disagree	2 (3)	0 (0)	0 (0)	0 (0)	2 (2)
	Agree	24 (35)	14 (82)	3 (50)	1 (50)	42 (45)
	Strongly Agree	41 (60)	3 (18)	3 (50)	1 (50)	48 (52)
	Some extent	4 (6)	11 (65)	3 (50)	0 (0)	18 (19)

To what extent does the maintenance of ICT resources influence integration of ICT in Biology teaching?	Large extent	26 (38)	3 (18)	1 (17)	0 (0)	30 (32)
	Very large extent	38 (56)	3 (18)	2 (33)	2 (100)	45 (48)
Number of streams in the school	1-3	60 (88)	10 (59)	2 (33)	1 (50)	73 (78)
	Over 3	8 (12)	7 (41)	4 (67)	1 (50)	20 (22)
School offer computer studies as an examinable subject	No	54 (79)	10 (59)	0 (0)	0 (0)	64 (69)
	Yes	14 (21)	7 (41)	6 (100)	2 (100)	29 (31)
Total		**68 (100)**	**17 (100)**	**6 (100)**	**2 (100)**	**93 (100)**

From analysis in Table 4.19 it can be observed that 75 % (n=70) said that training more teachers, buying more computers, training teachers more, and strict supervision of teachers were the factors that led to improved ICT integration in biology teaching. 73 % (n=68) of the principals often visited to observe teachers of biology while teaching in their respective classes. This was majorly in County, Extra - County and National schools. Principals rarely 89 % (n=83) delegated to HODs the supervision/ observation of teachers of biology. This was evident across all the categories of schools. To a large extent 90 % (n=84), principals' supervision influenced integration of ICT in biology teaching across all the categories of schools. There was inadequacy of computers across majority of the school categories. Only National schools had over 20 computers in their schools with sub-county and extra county schools being highly affected. Majority 74 % (n=69) of the computers in the schools were functional. Most of ICT resources in the schools were sometimes 51 % (n=47) being serviced. This was as a result of inadequate 92 % (n=86) budgetary allocation for ICT repairs in the schools.

Majority 52 % (n=48) strongly agreed that maintenance of ICT had an influence to the integration of ICT in biology teaching in secondary schools. To a very large extent 48 % (n=45) of the respondents agreed that the maintenance of ICT resources influenced integration of ICT in biology teaching. Over 50 % of the schools 'categories had 1-3 streams with only extra county schools having over 60 % more than 3 streams. Computer studies was not an examinable subject in most of Sub- County and County schools unlike in Extra-County and National schools where computer studies was an examinable subject.

4.5 Results and Discussions Based on Objectives of the Study

In this section of the study the analysis and discussion of results based on the objectives has been presented.

4.5.1 The Influence of Teacher's Gender on Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The first objective sought to establish whether teacher's gender has any significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O1}: There is no statistically significant influence of teacher's gender on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

To ascertain the truth of the assumption in the null hypothesis, independent sample t-test was carried out and the results are presented in Table 4.20.

Table 4.20

The t-Test for Difference in Integration of ICT Among Genders of Teachers of Biology

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ict integration in biology teaching	Equal variances assumed	.638	.426	-.416	131	.678	-.02285	.05498	-.13161	.08591
	Equal variances not assumed			-.417	129.503	.677	-.02285	.05479	-.13125	.08554

The results in Table 4.20 indicate that the t-value was not significant (t (131) = -0.416, P = .678). Therefore, the null hypothesis was accepted. However, the female gender had a higher mean score of 3.8000 while that of male gender was 3.7771. This means that teacher's gender has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

The results have been supported by findings from other studies which indicates that gender of the teacher has no influence on integration of ICT in teaching. Kadiri (2015) did a study on factors influencing ICT integration in Vihiga county and concluded that teacher's gender did not influence integration of ICT in teaching of English language. According to Chepkonga

(2015) sought to find out whether there exists a relationship between the principal's gender and ICT integration in management of public secondary schools in Nairobi County, Kenya. The study concluded that there was no significant relationship between the secondary school principals' gender and ICT integration in management of public secondary schools in Kenya. Sabic et al. (2022) did a study in upper secondary schools in Croatia and found only minor gender differences in self-efficacy. According Gebhardt et al. (2019) there is no significant influence in ICT integration in teaching between female and male teachers in secondary school across Europe.

Arkorfu et al. (2021) did a study to examine the integration of Information and Communication Technology in teaching in Senior High Schools in Ghana and concluded that there was no significant difference in gender and acceptance of ICT integration in teaching. Ait Hammou and Elfatihi (2019) did a study among language teachers in Morocco and concluded that there was no significant difference in using ICT in language teaching between the male and female English language teachers. Mogeni (2020) observed that using ICT for teaching does not appear to differ greatly in terms of gender the study therefore concluded that there was no significant difference in computer usage levels based on gender. Similarly, Saripudin et al. (2020) investigated gender differences in self-reported ICT experience and ICT literacy among first year graduate trainee teachers and concluded that male teachers on average worked with computers significantly for more hours per week than female teachers but the difference wasn't statistically significant.

According to Norris (2019) gender variable is not a predictor of ICT integration into teaching. Ezekiel and Ezekiel (2019) assert that male teachers in Nigeria had relatively higher levels of computer attitude and ability before computer implementation, but there is no difference between males and females regarding computer attitude and ability after the implementation of the technology. The study claims that quality preparation on technology can help lessen gender inequalities. Papaioannou and Kyriacos (2021) undertook a study on the Cyprus primary school principals' attitudes towards Information and Communication Technology (ICT) as well as their perceptions about the factors that facilitate or inhibit ICT integration in primary schools in Cyprus. The findings of this study reveal there was no significant difference in integration of ICT between the gender.

This study found that there is no statistically significant difference in integration of ICT between gender in biology teaching in public secondary schools in Kiambu County Kenya.

4.5.2 The Teacher's Age and the Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The second objective sought to establish whether teachers' age has a difference on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O2}: Teacher's age has no statistically significant difference on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of assumption in the null hypothesis, ANOVA test was carried out and the results are presented in Table 4.21.

Table 4.21

Difference Between Teachers Age and ICT Integration in Biology Teaching in Sampled Public Secondary Schools

ANOVA

ICT integration in biology teaching

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.222	3	.074	.736	.533
Within Groups	12.973	129	.101		
Total	13.195	132			

The results in Table 4.21 indicates that F value was not significant (F (3, 129) = .736 P= .533). Therefore, the null hypothesis was accepted. This indicates that teachers' age has no statistically significant difference on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

The results of this study are consistent with those of Consolata (2020) who reported that there was no relationship between teachers' age and the use of ICT implying that teachers' age is not a clear predictor of ICT integration. Chemwei and Koech (2014) reported that young teachers between 25-30 years of age appear to have greater interest in ICT than older teachers though there was no statistically significant difference in their integration of ICT. Langat (2020) in support adds that the younger teachers show great enthusiasm in the adoption and usage of ICTs in their daily life but on average they do not differ in their integration with older teachers. Mutisya (2020) carried out a study on age and gender differences in the overlooked context of individual adoption and sustained usage of technology in the workplace using the Theory of

Planned Behavior (TPB). Data was analyzed using descriptive statistics and presented in frequencies and percentages. The results showed that the decisions of men and younger worker are more strongly influenced by their attitude toward using the new technology. In contrast, women and older workers are more strongly influenced by subjective norm and perceived behavioral control. The groups were found to adopt very different decision processes in evaluating new technologies. Mutisya therefore did not find any significant influence of age on integration of ICT in teaching.

However, the results are inconsistent with findings by Har et al. (2019) who reported that age affects teachers' perceptions of ICT and its usage on management. The study explains that the younger, less experienced teachers are more likely to be ICT proficient. They have focus on educational courses on ICT and will be less constrained by prior attitudes or habit than their older more experienced colleagues. Mogeni (2020) observes that teachers' age has also been found to influence the adoption of an innovation, where younger teachers are more likely to use ICTs in their classes than older teachers. This has been attributed, partly, to the fact that new teachers have been exposed to ICTs during their training and therefore, have more experience using them than their predecessors. Bereczki and Kárpáti (2021) observed that older teachers, having successfully established routines of work that meet their criteria of good teaching, are reluctant to change their practice, especially if they do not understand the rationale for change in use of ICT and therefore age influences the integration of ICT in teaching. Gode (2013) investigated the factors influencing integration of information and communication technologies in public primary teacher training colleges in central region of Kenya.

The study adopted descriptive survey design. The results of the study showed that teachers of the age 40 years and below had formed large proportion of teacher trainers who adopted ICT. Edward (2015) carried out a study on principals' characteristics influencing integration of Information and Communication Technology in management of secondary schools in Makueni Sub-County. The study reveals that age affects teachers' perceptions of ICT and its usage on management. Young principals were seen to integrate ICT more compared to elderly principals a factor that was attributed to the fact that they went through an education system that had integrated ICT. Mogeni (2013) did a study to establish the influence of principals' characteristics on integration of Information Communication Technology in management of financial resources in Masaba District, Kenya. The study reveals that principal's age affected integration of ICT in schools where principals aged between 30 and 49 years showed higher

percentage of ICT integration than those aged between 50 and 60 years who were heading to retire.

4.5.3 Influence of Teacher's Competency in use of ICT on Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The third objective sought to examine whether teachers' competence has any influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O3}: Teacher's competence in use of ICT has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, Pearson correlation was carried out and the results are presented in Table 4.22 and 4.23. Table 4.22 gives the results of correlation coefficient between teacher's competency and integration of ICT in biology teaching.

Table 4.22

The Pearson correlation Coefficient Between Competency and Integration of ICT in Biology teaching

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.248[a]	.062	.054	.307	.062	8.605	1	131	.004

a. Predictors: (Constant), Teacher competency

The results in Table 4.22 indicates that the Pearson correlation coefficient between competence of the teacher and integration of ICT was significant (r= .248, p=.004). This means that teacher's competence in use of ICT and integration of ICT in teaching are not independent. The correlation coefficient is positive which means that any increase in competence lead to an increase in integration of ICT among teachers of biology in public secondary schools in Kiambu County. To ascertain whether the influence of competence on integration is statistically significant, simple regression analysis was done and the results are presented in Table 4.23.

Table 4.23

The Simple Regression Analysis of Competency on Integration of ICT in Biology Teaching

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.813	1	.813	8.605	.004[b]
	Residual	12.382	131	.095		
	Total	13.195	132			

a. Dependent Variable: ICT integration in biology teaching

b. Predictors: (Constant), Teacher competency

The results in the Table 4.23 indicate that F-value was significant (F (1, 131) =8.605, p=.004). Therefore, the null hypothesis is rejected. This implied that teacher's competence on use of ICT has a statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. Conclusion is made that teacher's competence makes a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. The results from this study have been supported by findings from other studies. Seifu (2020), observed that teacher's competence is a great determinant of integration of ICT in teaching. His findings pointed to the fact that teachers' competence was the second most inhibiting obstacle to the use of computers in schools. Similarly, in the United States, Tondeur et al (2021) hypothesized that high levels of competence would produce higher levels of technology integration that will reflect on student achievements positively. Their model postulated that educators with higher levels of skill, knowledge, and tools would exhibit higher levels of technology integration in the classroom. Moreover, Farjon et al. (2019) studied the relationship between computer use in the classroom and teachers' competency. The study found that the faculty's belief in their computer competence was the greatest predictor of their integration of computers in the classroom.

The results were further supported by Hirschbuhl and Faseyitan (2014) who observed that the technical orientation of the teacher is a significant predictor of integration. Mutisya (2014) noted that the competency to use ICT resources by teachers is gotten through in-service training, capacity building workshops and regular use of the ICT tool and it is an important factor in determining the integration of ICT in teaching. The study concludes that competence help principals to be confident in use of ICT tools in their daily practices. Ogachi (2015) asserts that the teacher's competence in use of ICT tools significantly influences the integration of ICT by the principals in their administrative task areas. A study by Mwikya (2014) investigated

factors influencing integration of information communication technology in public secondary schools in Migwani Sub-County, Kitui County, Kenya. The study findings revealed that integration of ICTs in the secondary schools was hindered by factors such as inadequate infrastructure and teachers' competence. This showed that a large percentage of the teachers had the ability to use the computers although their ICT skills are not so advanced. The current study therefore concludes that teacher's competence has statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

4.5.4 The Teacher's Teaching Experience and Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The fourth objective sought to establish whether there is a difference between teaching experience and integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O4}: Teacher's teaching experience has no statistically significant difference on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, ANOVA test was carried out and the results are presented in Table 4.24 and 4.25.

Table 4.24

ANOVA Test on Integration of ICT in Biology Teaching with Respect to The Teaching Experience

ANOVA

ICT integration in biology teaching

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.039	4	.260	2.734	.032
Within Groups	12.156	128	.095		
Total	13.195	132			

* The Mean difference is significant at the 0.05 level.

The ANOVA test in Table 4.24 indicates that the F- value is significant. (F (4, 128) = 2.734, p= .032). This means that there is statistically significant difference on integration of ICT in

biology teaching with respect to teaching experience. Therefore, the null hypothesis (H_{04}) was rejected at .05 level of significance.

The results in Table 4.24 did not reveal where the significant difference was and so there was the need for further analysis. The Turkey Highest Significant Difference (HSD) post Hoc analysis was done and the results presented in Table 4.25.

Table 4.25

Pairwise Difference in Mean Scores Among Teaching Experience Categories with Respect to the Integration of ICT

Multiple Comparisons

Dependent Variable: ICT integration in biology teaching

HSD

(I) Experience in teaching Biology	(J) Experience in teaching Biology	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
(1-5) Years	(6-10) Years	.007	.070	.921	-.13	.15
	(11-15) Years	-.128	.074	.088	-.28	.02
	(16-20) Years	-.022	.098	.819	-.22	.17
	Over 20 Years	.208*	.098	.035	.01	.40
(6-10) Years	(1-5) Years	-.007	.070	.921	-.15	.13
	(11-15) Years	-.135	.077	.082	-.29	.02
	(16-20) Years	-.029	.100	.769	-.23	.17
	Over 20 Years	.201*	.100	.046	.00	.40
(11-15) Years	(1-5) Years	.128	.074	.088	-.02	.28
	(6-10) Years	.135	.077	.082	-.02	.29
	(16-20) Years	.105	.103	.307	-.10	.31
	Over 20 Years	.336*	.103	.001	.13	.54
(16-20) Years	(1-5) Years	.022	.098	.819	-.17	.22
	(6-10) Years	.029	.100	.769	-.17	.23
	(11-15) Years	-.105	.103	.307	-.31	.10
	Over 20 Years	.231	.121	.058	-.01	.47
Over 20 Years	(1-5) Years	-.208*	.098	.035	-.40	-.01
	(6-10) Years	-.201*	.100	.046	-.40	.00
	(11-15) Years	-.336*	.103	.001	-.54	-.13
	(16-20) Years	-.231	.121	.058	-.47	.01

*. The mean difference is significant at the 0.05 level.

The results in Table 4.25 indicate that significant difference in the mean score were found between 1-5 and over 20 years, 6-10 and over 20 years, 11-15 years and over 20 years. Their mean differences were .208, .201 and .336 respectively) Their significance were, .035, .046 and .001 respectively which were statistically significant at .05 level of significance. However, there was no significant difference in integration of ICT for teachers with 6-10 years. In conclusion 11-15 years of experience group had the highest mean score followed by 1-5 years and eventually 6-10 years.

The results from this study are supported by Lawrence and Tar (2018) who did a study on factors that influence teachers' adoption and integration of ICT in teaching/learning process and concluded that teaching experience significantly influenced integration of ICT in teaching process Kushnir (2023) observed that teaching experience of a teacher is a key indicator to integration of ICT in teaching high school students. According to Li and Wong (2019) teaching experience influence the successful use of ICT in classrooms. According to Hernandez-Ramos (2015) teachers' teaching experience is widely linked with the use of ICT. Hafifah (2020) In an examination of teaching using computer technology reports that the level of experience with technology play a major role on how teachers use ICT. A study by Kiprono (2019) observed that one important factor that influenced the use of Computer Technology in Mathematics teaching was teachers teaching experience. Most research has shown that teacher experience is remarkably interrelated with the actual use of technology in teaching (Li & Wong, 2020).

Kumar et al. (2022) in a study revealed that effective use of ICT was related to technological comfort levels, teaching experience and the liberty to shape instruction to teacher-perceived student needs. Gilquin and Granger (2022), observes that one of the factors that determine the extent to which teachers use computers in their classes maybe the number of years they have been teaching. Some studies have shown that teaching experience has no influence on integration. Sharma (2020), reported that teachers‟ experience in teaching did not influence their use of computer technology in teaching". Tenai (2017) noted that over the years, computer usage issues related to various subjects taught have been debated in the literature. Though some research reported that teachers' experience in teaching did not influence their use of computer technology in teaching. The current study confirms that there is a statistically significant influence of teaching experience on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

4.5.5 The Influence of Availability of ICT Resources on the Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The fifth objective sought to examine whether the availability of ICT resources influence the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O5}: Availability of ICT resources has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, the Pearson correlation was carried out and the results are presented in Table 4.26.

Table 4.26

Pearson Correlation ***for the Influence of Availability of ICT on Integration in Biology Teaching***

Model Summary

					Change Statistics					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.269[a]	.029	.021	.313	.029	3.852	1	131	.002	1.892

a. Predictors: (Constant), availability of ICT in school

b. Dependent Variable: ICT integration in biology teaching

From Table 4.26, the Pearson correlation coefficient between availability of ICT resources and integration in biology teaching in public secondary schools in Kiambu County was positive and significant ($r = .269$, $p = .002$). This means that any increase in availability of ICT resources leads to an increase in integration of ICT among teachers of biology in public secondary schools in Kiambu County, Kenya.

To ascertain whether the influence of availability of ICT resources on integration in biology teaching in public secondary schools in Kiambu county was statistically significant, simple regression analysis was done and the results are presented in Table 4.27.

Table 4.27

The Simple Regression Analysis of the Availability of ICT and Integration Among Teachers of Biology in Public Secondary Schools in Kiambu County

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.813	1	.813	8.605	.002[b]
	Residual	12.382	131	.095		
	Total	13.195	132			

a. Dependent Variable: ICT integration in biology teaching

b. Predictors: (Constant), Availability of ICT

The results in Table 4.27 indicate that the F-value was significant F (1, 131) =8.605, p=.002). The null hypothesis is rejected. This means that availability of ICT resources has a statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County. Therefore, conclusion made is that availability of ICT resources made a significant contribution on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. The results were supported by other studies. For instance, a study by Muia (2021) on factors influencing the integration of ICT in teaching and learning in primary schools in Kitui-Central Sub-County from a sample of 90 teachers and 17 head teachers found that the availability of ICT resources had a statistically significant influence on teachers' ICT integration in teaching and learning in public primary schools in Kitui-Central Sub-County. This meant that most of the teachers who engaged in ICT integration came from schools with ICT resources. Similarly, Munje and Jita (2020) identified lack of software and lack of hardware as the main barriers for integrating ICT in pre-service teacher education programs. Buabeng – Andoh (2021) highlighted access to ICT infrastructure and resources in schools as a necessary condition to the integration of ICT in education.

According to Zehra (2021) effective adoption and integration of ICT into teaching in schools depends mainly on the availability and accessibility of ICT resources such as hardware and software. Mogeni (2020) posits that obviously if ICT resources are not available in school, teachers can neither access nor use them for teaching. Therefore, availability of ICT resources such as computers, updated software and hardware are key elements to successful adoption and integration of ICT in teaching. Another study by Yildrim et al. (2022), found that access to technological resources is one of the effective ways to teachers' pedagogical use of ICT in teaching in Turkey. According to Seifu (2020), access to computer and network both at school

and at home is important for teachers. He found insufficient computers and low access to the internet as barriers to integration of ICT into teacher training. In support Abel et al. (2022), found that availability and access to hardware and software is not only important but also support teaching and learning. Hasin and Nasir (2021) observed that the availability of ICT in Malaysian secondary schools seriously limited what a teacher can do in the classroom with regards to integration. Far from Asia and Europe, Caskurlu et al. (2020) noted that teachers used computers for teaching since they were present in their places of work. In addition, they notes that American secondary schools have successfully integrated ICT in teaching mostly due to the availability of the computers.

In support Shah (2022) did a study in Indonesian secondary schools and observed that teachers comfortably integrated ICT in teaching since computers are at their disposal. In addition, the study noted that teachers also use computers for their own work outside the school. Shah through his findings concluded that the main obstacle to technology integration in teaching worldwide is availability. Looking at availability of ICT and funds Hasin and Nasir (2021) states that many scholars proposed that the lack of funds to obtain the necessary hardware and software is one of the reasons why teachers do not use technology in their classes. A study on effects of availability of computers on integration in Saudi Arabia Universities, by Mahdi and Dera (2014), 78% of lecturers surveyed cited limited access to computers as a barrier to effectively integrating it computers in their classes. Of this, 38% thought inadequate computers were a great barrier to using technology in their classes. Therefore, efficient and effective use of technology by a large extent depends on the availability of hardware and software. Yildrim et al. (2022) in a study report revealed that over 50% of the respondents used computers for research and lesson preparation in their schools. About 78% of the respondents complained of inadequate access to computers in the classroom. Of this percentage, 38% of the respondents stated that inadequate computers were not great barriers to ICT use in their teaching, but improved availability and fairness of access to technology resources by teachers, students and administrative staff was essential.

Gikundi (2016) observes that though it is the government policy to integrate ICT in learning in public secondary schools in Kenya, there is no money factored in the Free Day Secondary Education Funds for ICT integration. In addition, he notes that, only a few schools have been given ICT facilities, but even with them no monitoring and evaluation has been done to ascertain ICT integration in teaching and learning. From the studies it can be agreed that

availability of ICT has a significant influence on integration in teaching. This study therefore confirms what other studies have found that the availability of ICT has a statistically significant influence on integration of ICT in Biology teaching in public secondary schools in Kiambu County.

4.5.6 The Influence of Principals' Supervision on the Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The sixth objective sought to examine whether principals' supervision has any influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O6}: Principals' supervision has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, Pearson correlation was carried out and the results are presented in Table 4.28 and 4.29.

Table 4.28 gives the results of Pearson correlation coefficient between the principals' supervision and ICT integration in biology teaching.

Table 4.28

Pearson Correlation Coefficient for Principals' Supervision and ICT Integration in Biology Teaching

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.166[a]	.028	.017	.426	.028	2.583	1	91	.111

a. Predictors: (Constant), Principals level of supervision

From Table 4.28, the Pearson correlation coefficient between principals' supervision and integration of ICT in biology teaching was not significant (r= .166, p=.111). This means that principals' supervision and integration of ICT are dependent.

To ascertain whether the influence of principals' supervision on integration of ICT is statistically significant, simple regression analysis was done and the results presented in Table 4.29.

Table 4.29

The Simple Regression Analysis of Principals' Supervision and Integration of ICT in Biology Teaching

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.469	1	.469	2.583	.111[b]
	Residual	16.523	91	.182		
	Total	16.992	92			

a. Dependent Variable: ICT integration in biology teaching by principals

b. Predictors: (Constant), Principals level of supervision

The results in Table 4.29 indicate that the F-value was not significant F (1, 91) =2.583, p =.111). The null hypothesis was accepted. This implies that principals' supervision has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools. Therefore, the conclusion made is that principals' supervision does not make a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu County.

The results were supported by other researchers who found that supervision of teachers by the principal does not make them integrate ICT in their teaching. The results were in agreement with Marey et al. (2020), who observed that in most cases supervision in public secondary schools doesn't influence integration since it focuses on inspection rather than supervision hence watering down the whole purpose of supervision. This means that supervision carried out is more looking for teacher errors than looking for solutions to problems and advising teachers. A few other studies available presents mixed reaction on this factor for instance, Obunga (2019) notes that meaningful integration of ICT may not take place in an environment with inadequate supervision while another study by Kiptum (2018) supports this by noting that quality of education depends on the nature of leadership provided by the principal especially instructional supervision. Romero-Rodríguez, et al. (2020), noted that principals as secondary schools' supervisors are responsible and expected to initiate activities that make teaching possible and learning process friendly to the learners such as use of technology in teaching. Mmari et al. (2023) indicates that its sole responsibility of the principal to supervise the use of technology in teaching and encourage its use. Aramide and Akinade (2016) noted that where principal use direct supervision of instructions, use of technology to teach is most likely to occur across all the teaching subjects.

The findings are contrary with Altun and Yengin (2020) who asserts that supervision is one of the things to consider if you want to improve on integration of ICT in teaching since it promotes integration of ICT in teaching learners in senior schools. Block (2014), in his research which involved 151 teachers, found that the principals' leadership and school climate jointly affected teacher work productivity and therefore concludes that supervision has a positive impact on integration in teaching high school learners. Marey et al. (2020) disagrees with this notion and adds that the principal characteristics affects integration and not supervision. Block, seems to support this notion by arguing that the principal plays an important role in coaching the teachers and ensuring teachers integrate the ICT well as they emulate him/her. Chatmaneerungcharoen (2019) disagrees with the current findings as well and states that the supervision carried out well has an impact on increasing the teacher's integration of ICT in teaching.

Yunus and Joblie (2022) states that the presence of supervisors also affects the characteristics of teachers which influences the integration of ICT. Gill et al. (2015) sums up by concluding that supervision has an effect on integration skills since it affects the teacher teaching practices. The study found that principal's supervision has no significant influence on integration of ICT in biology teaching in public secondary schools.

4.5.7 The Influence of Principals' Maintenance of ICT Resources on the Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The seventh objective sought to examine whether there is an influence of principals' maintenance of ICT resources on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{O7}: Principals' maintenance of ICT resources has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, the t-Test was carried out and the results are presented in Table 4.30.

Table 4.30

The t-Test for the Mean Maintenance Score Between ICT Maintained and Non- Maintained Schools

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ict integration in biology teaching	Equal variances assumed	.638	.426	.0031	131	.041	-.02340	.05488	-.13140	.08552
	Equal variances not assumed			.0032	129.503	.042	-.02340	.05469	-.13100	.08513

The Table 4.30 shows analysis of t-test indicating that with assumption of the equal variance, it can be observed that the t-value was significant (t (131) = .0031, p = .041). Therefore, the null hypothesis was rejected at .05 significance. This means that there is statistically significant influence on integration of ICT with respect to principals' maintenance of ICT resources favouring the public secondary schools with well-maintained resources having a mean of 4.890.

The results of this study were in agreement with Akinsanya (2020) who noted that the maintenance of ICT resources is an essential indicator of their integration in teaching at secondary school level. Akinsanya concludes that resources that are well maintained will attract the user while dilapidated and unkempt resources will discourage the users too. Studies related to the influence of maintenance of ICT tool on integration are very rare in the existing literature. However, the available studies seem to agree with the findings of the current study. For instance, in a recently study done by Asiabaka (2018), on effective management of schools in Nigeria, noted that the school heads had little concern on the state of resources and this led to poor state of ICT resources in secondary schools and apparently little or no integration in teaching. Similarly, Olaniyan and Ojo (2018) in their study noted that poor maintenance of ICT resources and subservicing of others were major challenges facing integration of ICT in Nigerian secondary schools. They added that most teachers used trial and error method to

connect laptop to the power and LCD projector which may cause the equipment to develop mechanical challenge.

In conclusion, Olaniyan and Ojo noted that poorly maintained ICTs frustrated the teachers' efforts to integrate the ICT in their teaching and eventually they don't attempt to integrate the ICT. This is supported by Sayo (2016) who noted that proper maintenance determined whether or not integration of ICT resources in teaching in secondary schools occurred successfully. Akinsanya (2020) observed that there was a general lax in principals when it comes to maintenance of resources which negatively affected the integration of ICT in teaching. According to a study by Issa (2021). The principal level of maintenance of ICT resources is directly correlated with the level of integration of technology in schools. He observed that schools in Nigeria where the principal took responsibility of regularly checking on the functionability of the ICT equipment in schools and repair or replace them, the teachers were motivated to integrate them. In contrast he notes that, where the resources are poorly maintained or neither serviced nor repaired, teachers showed laxity in integrating them to teach various science subjects. Mogeni (2020) in his study on instructional management noted that, most principals had a negative attitude and they reiterated that it was very expensive to maintain ICT resources and this led to poor usage of the resources in teaching. Muthoni, in support of this notes that most principals had issues when it came to maintenance of ICT resources and did not want to get bothered in regular repairs of ICTs (Muthoni, 2017) and hence the integration of the ICT resources was impaired.

Ngunjiri (2012) did a study in Rumuruti and reported that ICT teaching resources in research location were poorly stored, lacked good inventory and poorly maintained. He observed that poor storage leads to destruction of ICT resources and eventually the principals are hesitant to repair them. He concluded that poorly maintained ICT resources discouraged integration of ICT in teaching. Sayo (2016) confirms this by noting that the ICT equipment had no definite and agreeable storage space in majority of secondary schools which affected their maintenance. Mwangi (2014), posits that ICT resources were easily damaged such as in the course of being transferred and therefore their life span was greatly reduced and this added more harm to already poorly maintained resources. The study concluded that definitely this affected integration in teaching. Sayo specifically supported this by noting that LCD projectors were among the most poorly maintained and eventually poorly integrated ICT resource. A study by Otieno (2022), agrees with the current study's findings. Kagutu et al. did a study and evaluated

the influence of principals' maintenance of ICT equipment on usage of ICT for teaching and learning in secondary schools in Kisumu County, Kenya. The study used a mixed methods research design and stratified random sampling to select 99 principals from a study population of 132 in order to administer questionnaires on them. 28 principals, 28 deputy principals and 35 Heads of Department (HODs) were interviewed. Questionnaire reliability was ascertained at (r) = 0.739 using the split-half technique.

The results of that study revealed that principals' performance in maintenance of ICT equipment was above average and statistically significant (α= .287; $p<05$). The study concluded that principal's maintenance of ICT equipment significantly influenced usage of ICT for teaching and learning in secondary schools in Kisumu County. The current study has found that principal's maintenance of ICT has a positive relationship with integration of ICT biology teaching in Kiambu County public secondary schools. Marey et al. (2020) urges that when the ICT tools are well maintained the teacher can use them when he or she requires them and teachers are positive on integration in schools where resources are well-maintained. Marey et al. concludes that the teacher is assured of the ICT resources giving the right and expected results when well maintained. Muthoni (2017) state that on contrary, ICT tools that are not well maintained will waste a lot of time as the teacher try to fix them and may not work at the end of it all. In addition, the teacher maybe negative on using poorly maintained ICT resources. This study concludes that the maintenance of ICT resources has a significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

4.5.8 The Influence of Public Secondary School Size on the Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The eighth objective sought to examine whether the size of public secondary school has an influence integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

$H0_8$: Public secondary school size has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, the t-test was carried out and the results are presented in Table 4.31.

Table 4.31

The t-test for Integration of ICT in Biology Teaching mean scores between small and large secondary schools

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
ICT integration in biology teaching by principals	Equal variances assumed	.342	.560	.811	91	.419	.088	.109	-.128	.304
	Equal variances not assumed			.792	29.312	.435	.088	.111	-.139	.316

The results in Table 4.31 indicates that the t-value was not significant (t (91) = 0.811, p=0.419) hence the null hypothesis was accepted. This means that there was no statistically significant influence of the size of the public secondary school on integration of ICT in biology teaching in public secondary schools in Kiambu County. The results favored the small schools with a mean score of 3.39 as compared to large schools with a mean of 3.30.

This differed with study findings by Oduol (2020) which reveal that most of the small sized schools used both traditional and modern ICT related aspects in performing management functions but a slight difference is observed where larger sized schools seem to adopt and use modern ICT as compared to small day secondary schools. The results imply that large secondary schools had embraced modern ICT in the performance of management functions as compared to small schools. Muli et al. (2017) did a study in Kitui County and noted that principals in large boarding schools integrate ICT in management tasks more than those in small day schools. The results of this study are also not in agreement with those of Gacicio et al. (2021) who observed that school environment factors such as size of the school has a significant influence on integration of ICT in teaching and learning in public primary schools.

Mwikya (2014) observed that day secondary schools in Migwani district which are small in size had too few computers compared to the users in the schools. This not only limits the access

but it also becomes difficult to rely on them for teaching and learning. Wafula (2020) observes that most of the day schools had less than five computers most of which were used for clerical work in the school. Most of the schools did not had computers in the staffroom. This limited the teachers to use computers for their class presentation. Mwikya in his study also observed that only one school had a projector. This meant that even presenting the work prepared by the teachers could only be done through hard copies. This implied that school size influenced ICT integration. The current study may differ from those cited here since it was done in Kiambu County which is part of the Nairobi metropolitan region. The region is well endowed with resources and most secondary schools whether small or large in size have computers and other ICT resources at disposal of the teachers. The results obtained are therefore not consistent with prior studies done in rural counties which could be lacking in ICT resources.

4.5.9 Category of the Public Secondary School and Integration of ICT in Biology Teaching in Public Secondary Schools in Kiambu County, Kenya

The ninth objective sought to examine whether there is a difference in the category of the public secondary schools and integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated:

H_{09}: Category of the public secondary school has no statistically significant difference in the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

To ascertain the truth of the assumption in the null hypothesis, ANOVA test was carried out and the results are presented in Table 4.32.

Table 4.32

ANOVA Test on the Category of the Public Secondary School and Integration of ICT in Biology Teaching

ANOVA

ICT integration in biology teaching

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.529	3	.176	.954	.418
Within Groups	16.462	89	.185		
Total	16.992	92			

The ANOVA test in Table 4.32 indicate that the F-value is not significant (F (3,89 = .954, p= .418). Therefore, the null hypothesis (H_{o9}) was accepted. This means that there is no statistically significant difference of ICT integration in biology teaching with respect to the school category. The results were contrary with findings by Wangili (2017), who established that there was a significant difference in ICT integration between small day and large boarding public secondary schools in TransNzoia County in Kenya. However, Imamun (2021) disagrees with the current findings and states that, in public secondary schools in Nigeria more boarding schools have higher level of integration of ICT than day schools. Odhiambo (2019) confirms that public boarding secondary schools are well established and have better integration of ICT than public day secondary schools in Kwanza Sub-County. The current study has established that category of public secondary school has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

This chapter is divided into four sections, that is, summary of the findings, conclusions made based on the findings, the recommendations of the study and suggestions for further research.

5.2 Summary of the Study Findings.

This section presents the summary of results of data analysis based on objectives of the study.

5.2.1 Influence of teacher's gender on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The first objective was to establish whether teacher's gender has any influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County. To achieve the objective, the following null hypothesis was formulated:

H_{O1}: There was no statistically significant influence of teacher's gender on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the analysis revealed that;

i. The mean score for male teachers of biology was 3.7771 with a standard deviation of .33965
ii. The mean score for female teachers of biology was 3.8000 with a standard deviation of .29127
iii. The t-test between the mean scores for male and female teachers was found not significant (t (131) = -0.416, P- value= .678). This means that there was no significant difference in the mean scores and therefore none of the gender integrates ICT more than the other significantly.
iv. Null hypothesis (Ho_1) was accepted and conclusion made that neither the male nor female teachers of biology significantly integrate ICT more than the other in biology teaching.

5.2.2 Teacher's age and integration of ICT in biology teaching.

The second objective was to establish whether there is any difference in integration of ICT in respect to age in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following null hypothesis was formulated.

H_{O2}: There is no statistically significant difference in integration of ICT in respect to age in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the analysis revealed that;

i. The ANOVA test between the mean score for different ages of the teachers of biology was not significant (F (3,129) = .736 p=.533). This means that there was no significant difference in the integration of ICT in biology teaching with respect to the age of the teacher of biology.
ii. The null hypothesis (Ho_2) was accepted.
iii. There is no statistically significant difference in integration of ICT in biology teaching in respect to the age of teachers of biology in public secondary schools in Kiambu County, Kenya.

5.2.3 Influence of teacher competency in use of ICT on the integration of ICT in biology teaching.

The third objective sought to examine whether there is any influence of competency of teacher of biology on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. To achieve the objective, the following null hypothesis was formulated;

H_{O3}: Teacher's competency on use of ICT has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by data analysis revealed that;

i. The Pearson's correlation coefficient between competence and integration of ICT was positive and significant (r=.248, P =.004). This means that any increase in competence leads to increase in integration of ICT in biology teaching in public secondary schools.
ii. The regression analysis indicate that the F-value was significant (F (1,131) =8.605, P-=.004). This means that competence can predict integration of ICT in biology teaching in public secondary schools.
iii. The null hypothesis (H_{03}) was rejected and conclusion made that competence makes a significant contribution to the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

5.2.4 Teaching experience and integration of ICT in biology teaching.

The fourth objective was to establish whether teaching experience has any significant difference on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following hypothesis was formulated.

H_{O4}: There is no statistically significant difference in integration of ICT in respect to teaching experience in biology teaching in public secondary schools in Kiambu County, Kenya.

Results generated by the data analysis revealed that that;

i. The ANOVA test indicated that the F- value was significant (F (4,128) = 2.734, P= .032).
ii. The null hypothesis (H_{04}) was rejected.
iii. Teachers of biology with 1-5 years teaching experience has a mean score of 3.71 with a standard deviation of .314.
iv. Teachers of biology with 6-10 years teaching experience has a mean score of 3.70 with a standard deviation of .325.
v. Teachers of biology with 11-15 years teaching experience has a mean score of 3.84 with a standard deviation of .210.
vi. Teachers of biology with 16-20 years teaching experience has a mean score of 3.73 with a standard deviation of .359.
vii. Teachers of biology with over 20 years teaching experience has a mean score of 3.71 with a standard deviation of .370.
viii. The significance difference in the mean score were found between 11-16 years and over 20 years (mean difference =.336).
ix. The Post Hoc analysis indicate that the integration of ICT favoured teachers of biology with teaching experience of 11-15 years and those with over 20 years. But there was no significant difference in integration of ICT in teachers with experience of 16-20 years.

5.2.5 Influence of availability of ICT on integration in biology teaching

The fifth objective was to establish whether availability of ICT resources has any significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following null hypothesis was formulated.

H_{O5}: Availability of ICT resources has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the data analysis revealed that;

i. The Pearson's correlation coefficient between availability of ICT resources and integration of ICT in biology teaching was positive and significant (r = .169, p= .002). This means that availability of ICT resources leads to an increase in integration of ICT among teachers of biology in public secondary schools in Kiambu County.

ii. The regression analysis indicate that the F-value was significant F (1, 131) =8.608, p=.002) this means that availability of ICT resources can predict integration among teachers of biology in public secondary schools.

iii. The null hypothesis ($H0_5$) was rejected and conclusion made that availability of ICT resources makes a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

5.2.6 Influence of principals' supervision of teachers and maintenance of ICT resources on integration of ICT in biology teaching.

The sixth objective was to establish whether principal's supervision and maintenance of ICT resources has any significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following two hypotheses **H_{O6}** and **H_{O7}** were formulated;

H_{O6}: Principals' supervision has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the data analysis revealed that;

i. The Pearson's correlation coefficient between principals' supervision and integration of ICT in biology teaching was positive and not significant (r = .166, p= .111). This means that principals' supervision of teachers doesn't lead to an increase in integration of ICT among teachers of biology in public secondary schools in Kiambu county.

ii. The regression analysis indicate that the F-value was not significant F (1, 91) =2.583, p=.111) this means that principals' supervision cannot predict integration of ICT among teachers of biology in public secondary schools.

iii. The null hypothesis (H_{06}) was accepted and conclusion made that principals' supervision does not make a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya.

5.2.7 Influence of principals' maintenance of ICT resources on the integration in biology teaching.

In the sixth objective the researcher also sought to establish whether principal's maintenance of ICT resources has any significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the second part of the objective, the following hypothesis was formulated;

H_{O7}: Principals' maintenance of ICT resources has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the data analysis revealed that;

i. The t-value was significant (t (131) = .0031, p = .041).
ii. There is statistically significant difference on integration of ICT with respect to principals' maintenance of ICT resources. This means that there was a significant difference in the mean scores favouring schools with well-maintained ICT resources.
iii. The null hypothesis (H07) was rejected and conclusion made that principals maintenance of ICT makes a significant contribution to the integration of ICT in biology teaching in public secondary schools in Kiambu County.

5.2.8 Influence of Public Secondary School Size on the Integration of ICT in Biology Teaching

The seventh objective was to establish whether public secondary size has any significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following hypothesis was formulated.

H_{O8}: Public secondary school size has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the data analysis revealed that;

i. The mean score for small schools was 3.39 with a standard deviation of .427
ii. The mean score for large schools was 3.30 with a standard deviation of .445
iii. The t-test between the mean scores for small and large schools was found not significant (t (91) = 0.811, p =0.419). This means that there was no statistically significant difference in the mean scores and therefore none of the categories of the schools integrates ICT more than the other significantly.
iv. Null hypothesis (Ho_8) was accepted and conclusion made that neither the small nor the large schools significantly integrate ICT more than the other in biology teaching.

5.2.9 Influence of School Category on Integration of ICT in Biology Teaching

The eighth objective was to establish whether public secondary category has any significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. To achieve the objective, the following hypothesis was formulated.

H_{O9}: School category has no statistically significant influence on the integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya

The results generated by the data analysis revealed that;

i. The ANOVA test between the mean score for teachers of biology in the sub-county, county, extra- county and national public secondary schools' categories in Kiambu county was not significant (F (3,89=.954, p =.418). This means that there was no significant difference in integration of ICT in respect to the public secondary school category.
ii. The null hypothesis (Ho_9) was accepted.

5.3 Conclusions

Based on the findings of the study, the following conclusions were made:

i. Gender of the teacher does not make a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. Hence gender cannot be used as a predictor for ICT integration among teachers of biology in Kiambu County.
ii. Age of the teacher of biology in public secondary schools has no statistically significant influence on integration of ICT in teaching in public secondary schools

in Kiambu County, Kenya. Therefore, age cannot be used as a predictor for ICT integration among teachers of biology in Kiambu County.

iii. Teachers of biology competency makes a significant contribution to the integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. Hence, competency can be used as a predictor for ICT integration among teachers of biology in Kiambu County.

iv. There is significant difference on ICT integration among teachers of biology in respect to teaching experience. Therefore, teaching experience can be used as a predictor for ICT integration among teachers of biology in Kiambu County.

v. Availability of ICT resources makes a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. Availability can be used as a predictor for ICT integration among teachers of biology in Kiambu County.

vi. Principals' supervision does not make a significant contribution to integration of ICT in biology teaching in public secondary schools in Kiambu county, Kenya. Therefore, the principal supervision cannot be used as a predictor for ICT integration among teachers of biology in Kiambu County.

vii. Principal's maintenance of ICT promotes integration of ICT significantly in biology teaching in public secondary schools in Kiambu County, Kenya. The study concludes that principals maintenance of ICT can be used as a predictor for ICT integration among teachers of biology in Kiambu County.

viii. There is no significant difference in integration of ICT among public secondary school teachers of biology with respect to school size in Kiambu County, Kenya. Therefore, public secondary schools size cannot be used as a predictor for ICT integration among teachers of biology in Kiambu County.

ix. Public secondary school category has no statistically significant influence on integration of ICT in biology teaching in public secondary schools in Kiambu County, Kenya. Therefore, public secondary school category cannot be used as a predictor for ICT integration among teachers of biology in Kiambu County.

5.4 Recommendations

This section consists of recommendations based on the results of the study as per the objectives. The study found that there is a significant influence of the competency in use of ICT, teaching experience, availability of ICT, and principal's maintenance of ICT resources on integration of

ICT in biology teaching in public secondary schools in Kiambu county, Kenya. In view of the findings, it is recommended that;

i. Teachers being employed in senior secondary schools for Competency Based Education (CBE) by Teachers Service Commission (TSC) should be properly inducted by the board of management on the aspect of integration of ICT in teaching in secondary school level to make them competent particularly in biology teaching and science subjects in general.
ii. The Teachers Service Commission (TSC) should motivate teachers to take ICT technician courses in order to assist public secondary schools in repairs and maintenance of ICT resources. This maybe by introducing ICT allowance to teachers who will willingly undertake a computer repair and maintenance course in designated institutions and universities. This will be a cheaper method of maintenance of ICT resources.
iii. Ministry of basic education and early learning should allocate some money to public secondary schools in order to use it to maintain ICT resources.
iv. Teachers' in-service training courses should also inculcate integration of ICTs to ensure teachers are constantly updated on new trends and development in ICT integration in their teaching.
v. The ministry of basic education and early learning should provide or assist public schools get free or affordable, fully established and reliable internet access. It should also lower tariffs, taxes and duty on ICTs and internet facilities to make them more affordable so that the teacher and learners can access or use them in schools and outside school.

5.5 Suggestions for Further Research

The current study has the following suggestions for further studies that can be undertaken to understand more about integration of ICT in teaching various subjects in secondary schools.

The following are areas that need further research;

i. Comparative study involving integration of ICT in public and private schools in Kiambu county, Kenya.
ii. The study recommends further research to be undertaken to establish how use of personal ICT resources such as smart phone and personal computers (PC) can influence the integration of ICTs in teaching in secondary schools.

iii. Further study can be done to determine how and the extent to which the use of ICT resources outside classrooms assists teachers in the integration of ICTs in teaching in secondary schools.

iv. The study recommends further research to investigate the influence of teacher's length of stay in a school on the integration of ICTs in teaching in secondary schools.

v. Studies can be done to investigate the influence of principals related factors on the integration of ICTs in teaching in secondary schools.

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APPENDICES

Appendix A: Introductory Letter

Isaac Gachuiga
P.O. Box 60081-00200
Nairobi.
5th July, 2017

Dear Sir/ Madam,

RE: PARTICIPATION IN RESEARCH

I am a post-graduate student at the **Laikipia University** pursuing a Doctor of philosophy (ph.D) in education. I am conducting research on influence of Personal and school level factors on integration of Information Communication Technology (ICT) in biology teaching in public secondary schools in Kiambu County, Kenya.

I am kindly requesting you to assist me collect data by filling the enclosed questionnaire. Please give your responses as per the questionnaire items and comment in the given spaces where applicable.
Do not write your name or identity on the questionnaire.

Thank you.

Yours faithfully,
Isaac Gachuiga

Appendix B: Questionnaire for the Teachers of Biology

This questionnaire is part of my PhD study that I am undertaking at Laikipia University. The purpose of the study is to investigate **influence of Personal and school level factors on integration of ICT in Biology teaching in public secondary schools in Kiambu County, Kenya**. In that regard, this questionnaire is meant to collect data on the aforementioned. The knowledge gained by the researcher from your responses will help in providing useful data for the current study as well as for informing policy/decision making in the area of educational technology. All information you provide will be kept strictly confidential and under no circumstances will your individual responses be disclosed to the school or any other person whatsoever. Please omit your name and that of your institution. Respond to ALL the items as clearly and accurately as you can. I greatly appreciate your taking time to complete this questionnaire. The questionnaire has four sections; A, B, C and D.

N/B: Some questions may have more that responses.

SECTION A: GENERAL INFORMATION

1. What category of school are you currently teaching?

   National [ ] Extra- County [ ] County [ ] Sub-County [ ]

2. Which age category do you belong?

   20-30 years [ ] 31-40 years [ ] 41-50 years [ ] 51-60 years [ ]

3. Indicate your gender.

   Male [ ] Female [ ]

4. Indicate your experience in teaching biology.

   1-5 years [ ] 6-10 years [ ] 11- 15 years [ ] 16-20 years [ ] over 20 years [ ]

5. Indicate your highest professional qualification in ICT.

   Certificate [ ] Diploma [ ] Bachelor degree [ ] Master [ ] PhD [ ]

SECTION B: AVAILABILITY OF ICT IN SCHOOLS

1. Indicate the adequacy of the following ICT resources in your school for use in teaching of Biology.

	Not available at all	In adequate	Fairly adequate	Adequate
i. Computers				
Internet				
Digital cameras				
Projectors				
Interactive whiteboard				
Computer Laboratory				
. Video conferencing equipments				

2. How often do use your personal computer in biology teaching?

Not at all	Rarely	Sometimes	Often	Always

3. Indicate how often do you access ICT resources in the following locations in the school?

Location	**Never**	**Rarely**	**Sometimes**	**Always**
Computer lab				
Classroom				
Resource center				
Library				
Staffroom				
Boardroom				

4. Indicate the availability of the following computer applications software in your school.

Software	Not available	Inadequate	Fairly available	Adequate
Ms word				
Ms excel				
Ms powerpoint				
Crocodile biology				

Pro biology				

SECTION C: COMPETENCY

5. Computer skills are essential in the life of a teacher.

(KEY. SA – strongly agree, A – Agree, D-Disagree, SD- Strongly Disagree).

SA	A	D	SD

6. Rank your use of computers to develop materials/aids for teaching.

Not at all	Sometimes	Often	Always

7. Rank the following statements based on your belief in using computers.

(KEY. SA – strongly agree, A – Agree, D-Disagree, SD- Strongly Disagree).

Belief of using computers	**SA**	**A**	**D**	**SD**
Using computers for teaching does fit my teaching style				
Computers have limited use in the secondary school classroom				
ICTs are best used for reinforcement of skills taught biology				
Computers have considerable potential for allowing students to discover or construct ideas for themselves				

8. Please use the items in the following scale to rate your competency for the integration of ICT in teaching: **(KEY. SA – strongly agree, A – Agree, D-Disagree, SD- Strongly Disagree).**

Statement	S D	D	A	SA
1 feel confident working on a computer				
I feel confident installing software				
I feel confident organizing and managing files				
I feel confident learning about computer hardware				
1 feel confident learning about computer software				
1 feel confident learning advanced skills of using computer programs				
I feel confident getting help on problems related to computers				
I feel confident surfing the internet				
I feel confident integrating ICT in instruction				
I feel confident developing simple programs for the computers				

9. How would you rate your level of expertise in computer use when teaching biology?
(KEY. VG – Very Good, G – Good, P-Poor, VP- Very Poor).

S/no	Expertise	VG	G	P	VP
1	Able to carry out computer booting functions				
2	Able to carry out basic computer functions				
3	Able to use word processor and spreadsheet for teaching in a biology lesson				
4	Able to use internet and open sourcing for teaching biology				
5	Able to comfortably use e-mails for communication				

10. Indicate your degree of competence for the following ICT resources in integration in your Biology teaching.

No.	ICT resources	Very competent	Competent	Less competent	Not competent

1.	CDS				
2.	DVDS				
3.	Power Point				
4.	You Tube				
5.	Animations				
6.	Captions				

SECTION D: INTEGRATION OF ICT IN TEACHING BIOLOGY

11. Indicate your degree of preference in integrating following ICT resources in teaching Biology.

S/No	ICT resource	Most preferred	Preferred	Less preferred	Not preferred
1	CDs				
2	DVDs				
3	Power point				
4	You tube				
5	Animations				
6	Captions				

12. Indicate how often you use computers for executing the areas listed here under.

	Everyday	**Occasionally**	**Rarely**	**Never**
For typing work				
Keeping records				
For games				
Communication				
For teaching				

13. Please read the descriptions of each of the six stages related to the process of integrating ICT in teaching activities and rank them.

STAGE	Very comfortable	Somewhat comfortable	Would like
Awareness: I am aware that ICT exist but have not used it.			
Learning: I am learning basics, though I have no confidence using ICT.			
Understanding: I do understand the process of using ICT in teaching.			
Familiarity: I am gaining a sense of self-confidence in using the computer for teaching			
Adaptation: I think about computer as an instructional tool and I can use many different computer applications for teaching biology.			
Creative application: I can apply what I know about technology in class and am able to use it as an instructional aid and have fully integrated computers into the curriculum			

14. Please indicate the extent to which you agree or disagree with each statement.
(KEY. SA – strongly agree, A – Agree, N-Neutral, D-Disagree, SD- Strongly Disagree).

Integration of ICT in teaching Biology	SA	A	N	D	SD
ICT provides a rich environment within which to create activities for students					
ICT provides valuable facilities to support student learning					
Only CDs distributed by KICD are available in schools for teaching Biology					
ICT is good for teacher lesson preparation and not for classroom teaching					
It is interesting to integrate various ICT facilities in teaching different biology skills because they make the subject matter more interesting.					

ICT helps the learners access authentic and up-to-date information					
Integration of ICT in teaching and learning makes learning interesting because learners are involved fully in the learning activities					
Integration of ICT makes me more productive and enhances student's learning					
Integration of ICT in teaching is scaring and am reluctant to adopt					
I would like to learn more about ICT integration					
ICT helps me organize my teaching activities					
ICT Integration consumes a lot of time and delays my syllabus coverage					
Am able to integrate ICT in teaching due to lack of computer facilities in my school					

15. Please indicate the frequency of integration of the following ICT resources into your teaching activities of Biology in the classroom.

Serial No	**ICT facilities**	**Always**	**Sometimes**	**Rarely**	**Never**
1.	CDs				
2.	DVDs				
3.	Power Point presentation				
4.	Internet				
5.	You Tube				
6.	Captions				
7.	Animation				
8.	Hyperlinks				
9.	Social media				
	Others (Specify)				

16. The following are challenges that affect the integration of ICT in teaching of Biology in your school. Kindly indicate your feeling on how you agree.

Challenge	SA	A	D	SD
Lack of adequate ICT skills				
Lack of motivation to use ICT				
Inadequate power supply				
Limited time to access the lab				
Inadequate infrastructure				
Bureaucracy in getting access				
Limited ICT facilities				
Inadequate internet services				
Lack of hands on experience				
Management of the lab equipment's				
Lack of ICT policy				
Others ***(please specify)***				

(KEY. SA – strongly agree, A – Agree, D-Disagree, SD- Strongly Disagree*).*

Appendix C: Questionnaire for the Principals

This questionnaire is part of my PhD study that I am undertaking at Laikipia University. The purpose of the study is to investigate **influence of personal and school level factors on integration of ICT in Biology teaching in public secondary schools in Kiambu County, Kenya**. In that regard, this questionnaire is meant to collect data on the aforementioned. The knowledge gained by the researcher from your responses will help in providing useful data for the current study as well as for informing policy/decision making in education. All information you provide will be kept strictly confidential and under no circumstances will your individual responses be disclosed to any person whatsoever. Please omit your name and that of your institution. Respond to ALL the items as clearly and accurately as you can. I greatly appreciate your taking time to complete this questionnaire. The questionnaire has three sections; A, B, C and D.

N/B: Some questions may have more than one correct response.

SECTION A: SUPERVISION OF TEACHERS OF BIOLOGY AND ITS INFLUENCE ON INTEGRATION OF ICT

1. How can principals improve ICT integration in Biology teaching?
   a. Training more teachers [ ]
   b. Buying more computers [ ]
   c. Training teachers more [ ]
   d. Strict supervision of teachers [ ]
   e. Providing internet [ ]
2. How often do you visit to observe teachers of Biology while teaching in their respective classes?
   a. Never [ ]
   b. Rarely [ ]
   c. Sometimes [ ]
   d. Often [ ]
   e. Always [ ]
3. How often do you delegate to HODs the supervision/ observation of teachers of Biology?
   a. Never [ ]
   b. Rarely [ ]
   c. Sometimes [ ]
   d. Often [ ]
   e. Always [ ]
4. To what extent does the principals' supervision influence integration of ICT in Biology teaching?
   a. No extent [ ]
   b. Little extent [ ]
   c. Some extent [ ]
   d. Large extent [ ]
   e. Very large extent [ ]

SECTION B: MAINTENANCE OF ICT RESOURCES AND ITS INFLUENCE ON INTEGRATION OF ICT

5. How many computers do you have in your school?
   a. 1-5 [ ]
   b. 6-10 [ ]
   c. 11-15 [ ]
   d. 16-20 [ ]
   e. More than 20 [ ]
6. Of the total computers in your school how many are functional?
   a. 1-5 [ ]
   b. 6-10 [ ]
   c. 11-15 [ ]
   d. 16-20 [ ]
   e. More than 20 [ ]
7. How often do you service ICT resources in your school
   a. Never [ ]
   b. Rarely [ ]
   c. Sometimes [ ]
   d. Often [ ]
   e. Always [ ]
8. How enough is the budgetary allocation for ICT repairs in your school?
   a. Very enough [ ]
   b. Enough [ ]
   c. Not enough [ ]
9. In your own opinion, do you think maintenance of ICT has an influence to the integration of ICT in biology teaching in secondary schools?
   a. Strongly agree [ ]
   b. Agree [ ]
   c. Disagree [ ]
   d. Strongly disagree [ ]
10. If yes (in the 6 above), to what extent does the maintenance of ICT resources influence integration of ICT in Biology teaching.
    a. No extent [ ]
    b. Little extent [ ]
    c. Some extent [ ]
    d. Large extent [ ]
    e. Very large extent [ ]

SECTION C: SIZE OF THE SCHOOL AND ITS INFLUENCE ON INTEGRATION OF ICT IN TEACHING

11. How many streams does your school has?
    a. 1 to 3 streams [ ]
    b. 4 or more streams [ ]
12. According to your opinion, to what extent do you think the size of the school influence integration of ICT in biology teaching?
    a. No extent [ ]
    b. Little extent [ ]
    c. Some extent [ ]
    d. Large extent [ ]
    e. Very large extent [ ]
13. What principals' related factors do you think influences ICT integration in teaching.

……
……

SECTION D: CATEGORY OF THE SCHOOL AND ITS INFLUENCE ON INTEGRATION OF ICT IN TEACHING

14. What is the category of your school?
    a. National [ ]
    b. Extra- County [ ]
    c. County [ ]
    d. Sub-County [ ]
15. Does your school offer computer studies as an examinable subject?
    a. Yes [ ]
    b. No [ ]
16. In your own opinion, to what extent do you think category of school influence integration of ICT in teaching.
    a. Great extent [ ]
    b. Some extent [ ]
    c. Undecided [ ]
    d. Less extent [ ]
    e. No extent [ ]
17. Please indicate the extent to which you agree or disagree with each statement.

(KEY. SA – strongly agree, A – Agree, N-Neutral, D-Disagree, SD- Strongly Disagree).

Integration of ICT in teaching Biology	**SA**	**A**	**N**	**D**	**SD**
ICT provides a rich environment within which to create activities for students					
ICT provides valuable facilities to support student learning					
ICT helps the learners access authentic and up-to-date information					
Integration of ICT in teaching and learning makes learning interesting because learners are involved fully in the learning activities					
Integration of ICT makes teachers more productive and enhances student's learning					
ICT helps teachers organize their teaching activities					
ICT Integration consumes a lot of time and delays syllabus coverage					

Appendix D: Consent Form

Title of Project : Influence of personal and school level factors on integration of Information Communication Technology (ICT) in biology teaching in public secondary schools in Kiambu County, Kenya.

Principal Investigator **:**Isaac Ndegwa Gachuiga

Cell no. 0721 429 603/ 0731558 668

Email. gachuigaisaac@gmail.com

1. **Purpose of the Study**: The purpose of this study is to investigate the influence of selected factors on integration of Information Communication Technology (ICT) in biology teaching in public secondary schools in Kiambu County, Kenya.
2. **Procedures to be followed:** The researcher will seek permission from the school principals upon presenting a letter of authority to collect data from Laikipia University. You will be asked to respond to questionnaire items.
3. **Discomforts and Risks**: The information provided will be for research purpose only and it will be held highly confidential. Under no circumstances will the information provided be used for other purpose other than academic research. However, the respondent is free to withdraw from the study in case they feel uncomfortable.
4. **Benefits:** The research will be an eye opener to teachers of biology since they can be used by teachers of biology and different ways in which ICT is used to teach biology. The principals will also be able to gain a lot of knowledge as heads of institutions on supervision of teachers of biology and maintenance of ICT resources in the schools. This will lead to academic performance improvement in their schools.
5. **Duration/Time:** The research will take approximately 20 minutes of your time. You can fill and return the questionnaire on the spot or fill it at your comfort and have the researcher pick it at a later date.
6. **Statement of Confidentiality:** Your participation in this research is confidential and there is no need to indicate your name. The data will be stored and secured by the researcher in a protected file. Laikipia university institutional ethics review committee may review records related to this research study. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared.

7. **Voluntary Participation:** Your decision to be in this research is voluntary. You can stop at anytime. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise.

You must be 18 years of age or older to consent to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign and indicate the date in the space below.

If you require, you will be given a copy of this consent form for your records.

_____ _____

Participant Signature Date

The informed consent procedure has been followed.

_____ _____

Person Obtaining Consent (Investigator) Date

Appendix E: Krejcie and Morgan Table of Determining Sample Size

Table 3.1

Table for Determining Sample Size of a Known Population

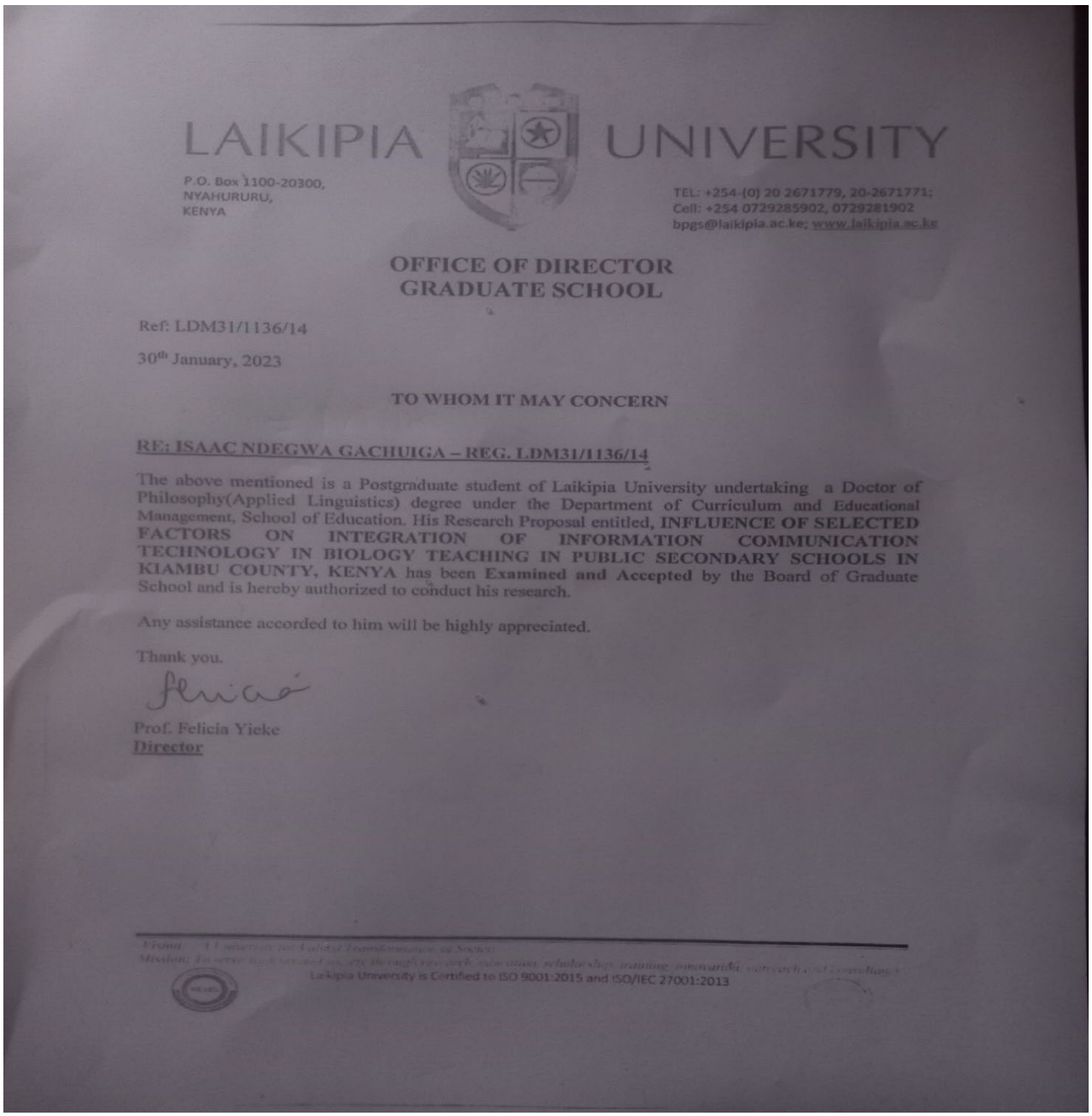
N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Appendix F: Map of Kiambu County in Kenya

Appendix G: Map of Kiambu County

Appendix H: Introduction Letter by Laikipia University Graduate School



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OFFICE OF DIRECTOR
GRADUATE SCHOOL

Ref: LDM31/1136/14

30th January, 2023

TO WHOM IT MAY CONCERN

RE: ISAAC NDEGWA GACHUIGA – REG. LDM31/1136/14

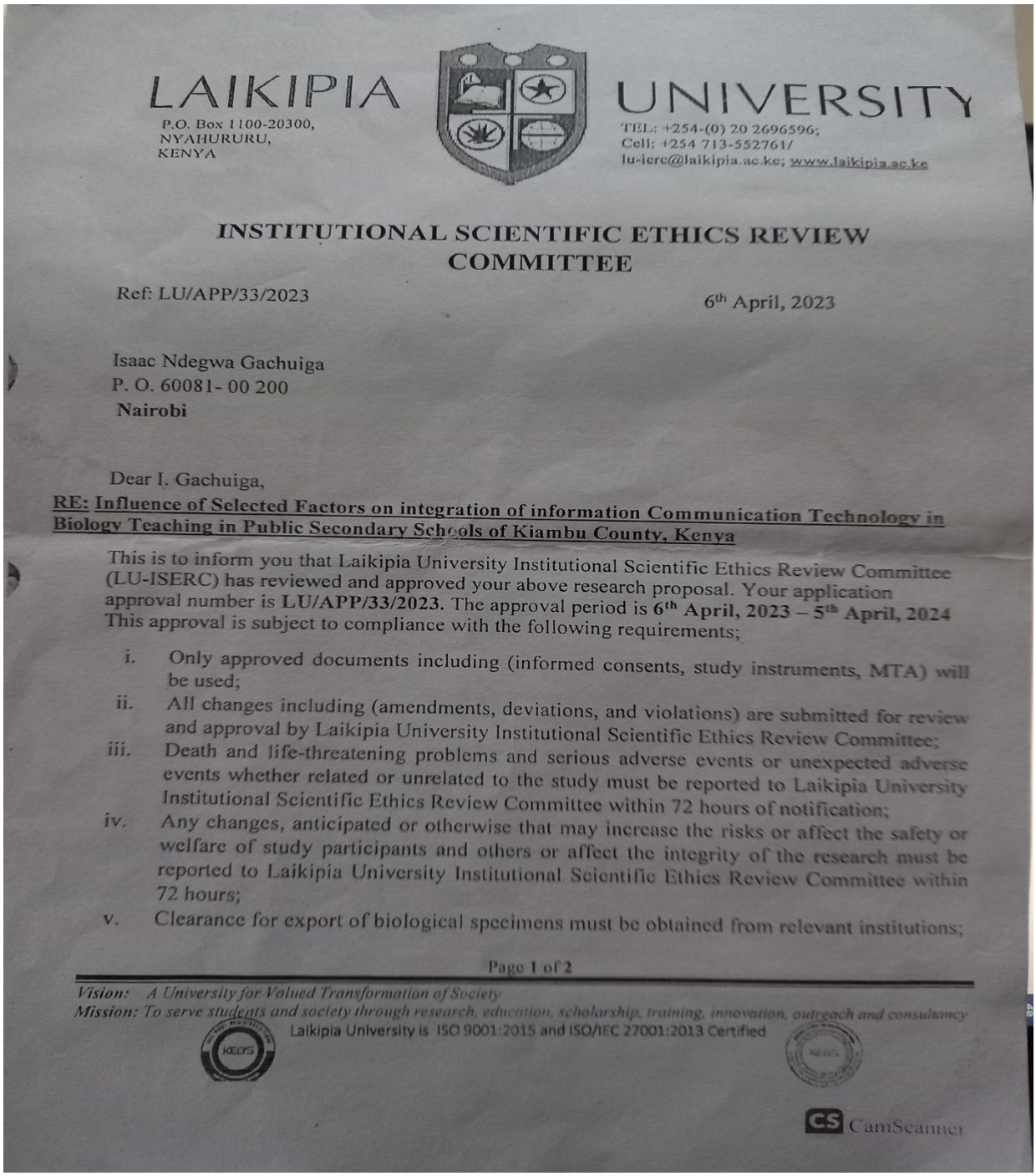
The above mentioned is a Postgraduate student of Laikipia University undertaking a Doctor of Philosophy(Applied Linguistics) degree under the Department of Curriculum and Educational Management, School of Education. His Research Proposal entitled, **INFLUENCE OF SELECTED FACTORS ON INTEGRATION OF INFORMATION COMMUNICATION TECHNOLOGY IN BIOLOGY TEACHING IN PUBLIC SECONDARY SCHOOLS IN KIAMBU COUNTY, KENYA** has been **Examined and Accepted** by the Board of Graduate School and is hereby authorized to conduct his research.

Any assistance accorded to him will be highly appreciated.

Thank you.

Prof. Felicia Yieke
Director

Appendix I: Letter by Ethics Committee



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INSTITUTIONAL SCIENTIFIC ETHICS REVIEW COMMITTEE

Ref: LU/APP/33/2023

6th April, 2023

Isaac Ndegwa Gachuiga
P. O. 60081- 00 200
Nairobi

Dear I. Gachuiga,

RE: Influence of Selected Factors on integration of information Communication Technology in Biology Teaching in Public Secondary Schools of Kiambu County, Kenya

This is to inform you that Laikipia University Institutional Scientific Ethics Review Committee (LU-ISERC) has reviewed and approved your above research proposal. Your application approval number is **LU/APP/33/2023.** The approval period is **6th April, 2023 – 5th April, 2024** This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used;
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by Laikipia University Institutional Scientific Ethics Review Committee;
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to Laikipia University Institutional Scientific Ethics Review Committee within 72 hours of notification;
iv. Any changes, anticipated or otherwise that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to Laikipia University Institutional Scientific Ethics Review Committee within 72 hours;
v. Clearance for export of biological specimens must be obtained from relevant institutions;

Vision: A University for Valued Transformation of Society
Mission: To serve students and society through research, education, scholarship, training, innovation, outreach and consultancy

Laikipia University is ISO 9001:2015 and ISO/IEC 27001:2013 Certified

vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal and

vii. Submission of an executive summary report within 90 days upon completion of the study to Laikipia University Institutional Scientific Ethics Review Committee.

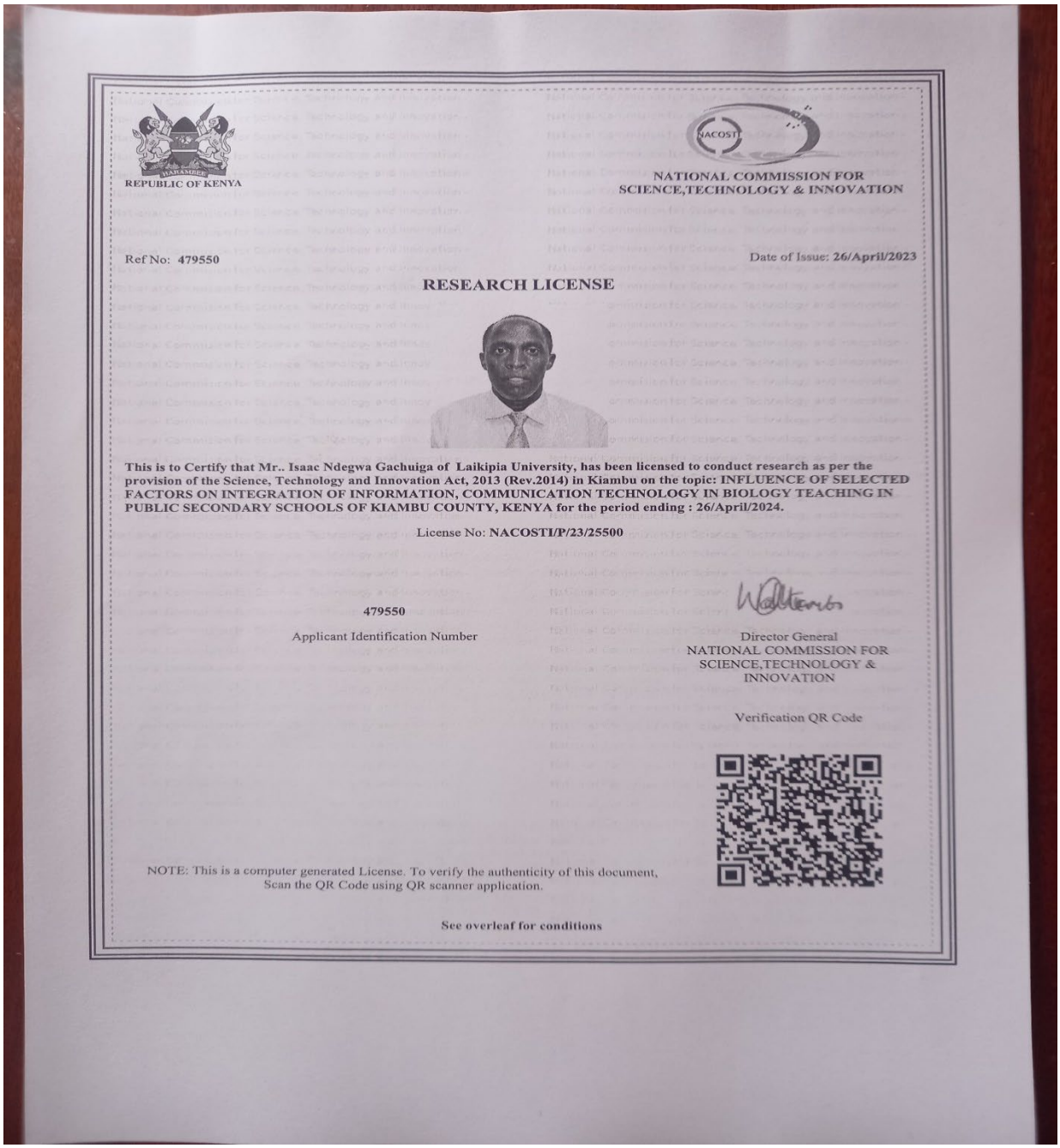
Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely

Prof. Charles Nguta PhD

Chairman - Laikipia University Institutional Scientific Ethics Review Committee

Appendix J: Research License from NACOSTI



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 479550

Date of Issue: 26/April/2023

RESEARCH LICENSE

This is to Certify that Mr.. Isaac Ndegwa Gachuiga of Laikipia University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kiambu on the topic: INFLUENCE OF SELECTED FACTORS ON INTEGRATION OF INFORMATION, COMMUNICATION TECHNOLOGY IN BIOLOGY TEACHING IN PUBLIC SECONDARY SCHOOLS OF KIAMBU COUNTY, KENYA for the period ending : 26/April/2024.

License No: **NACOSTI/P/23/25500**

479550

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)

Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
    i. Endanger national security
    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
    vii. Endanger public safety and national cohesion
    viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and
Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix K: List of Sampled Public Secondary School in Kiambu County

S/NO	SCHOOL	CATEGORY
1	Mangu High school	National
2	Limuru Girls	National
3	Githiga High school	Extra-County
4	Kijabe Boys	Extra-County
5	Nduberi Girls	Extra-County
6	St Joseph Boys- Githunguri	Extra-County
7	Senior Chief Koinange Girls	Extra-County
8	Kanunga high	Extra-County
9	Riabai Boys High school	County
10	Thigio boys High	County
11	Ituru Boys High	County
12	Karinga Girls High	County
13	Muthiga Girls secondary	County
14	Mutunguru Mixed Secondary	County
15	Kikuyu Boys High	County
16	Gachoire Girls High	County
17	Gathirimu Girls Technical High	County
18	Gitwe Girls High	County
19	Komothai Boys High	County
20	Gathiruini Boy High	County
21	JG. Kiereini Boys High	County
22	Gakoe Girls High	County
23	Makwa Boys High	County
24	Kirangari Boys High	County

25	Uthiru Girls High	County
26	St. Joseph Riabai Mixed	Sub-County
27	ACK Kiu River mixed secondary	Sub-County
28	Tinganga Mixed day	Sub-County
29	St . Peters Ndemberi	Sub-County
30	Juja Mixed Secondary	Sub-County
31	Gachororo mixed	Sub-County
32	Murera Mixed	Sub-County
33	Theta Mixed	Sub-County
34	Kimuchu Mixed	Sub-County
35	Thika Garrison mixed	Sub-County
36	Gichuru Mixed	Sub-County
37	Rironi Mixed	Sub-County
38	Mukoma Boys secondary	Sub-County
39	Kamirithu Mixed	Sub-County
40	Ngenda Secondary	Sub-County
41	Gitare Mixed	Sub-County
42	Gikure Mixed Secondary	Sub-County
43	Ndarugu Mixed Secondary	Sub-County
44	Handege Mixed Secondary	Sub-County
45	Githuya Mixed Secondary	Sub-County
46	Karai Mixed Secondary	Sub-County
47	Nachu Mixed Secondary	Sub-County
48	Lusigetti Senior Mixed Secondary	Sub-County
49	Kagaa Mixed Secondary	Sub-County
50	St. Augustine Nyanduma Mixed Secondary	Sub-County

51	Gathima Mixed Secondary	Sub-County
52	Kirenga Mixed Secondary	Sub-County
53	Gitithia Mixed Secondary	Sub-County
54	Mukua Mixed Secondary	Sub-County
55	Nyaga Mixed Secondary	Sub-County
56	Gathanji Mixed Secondary	Sub-County
57	Kanjai Mixed Secondary	Sub-County
58	Kahunira Mixed Secondary	Sub-County
59	Githunguri Technical Mixed Secondary	Sub-County
60	Gathaithi Mixed Secondary	Sub-County
61	Gikanga Kageche Mixed Secondary	Sub-County
62	William Ngiru Gitau Mixed Secondary	Sub-County
63	Kamondo Mixed Secondary	Sub-County
64	PCEA Ngemwa Mixed Secondary	Sub-County
65	PCEA Matuguta Mixed Secondary	Sub-County
66	PCEA Karia Mixed Secondary	Sub-County
67	Gathugu Mixed Secondary	Sub-County
68	Githima Mixed Secondary	Sub-County
69	Thuita Mixed Secondary	Sub-County
70	Kagema Mixed Secondary	Sub-County
71	Ruiru Girls Secondary Mixed Secondary	Sub-County
72	Kwihota Mixed Secondary	Sub-County
73	Devki Ruiru Township Mixed Secondary	Sub-County
74	Githurai Mixed Secondary	Sub-County
75	Uhuru Kenyatta Mixed Secondary	Sub-County
76	Kwangethe Mixed Secondary	Sub-County

77	Mwihoko Mixed Secondary	Sub-County
78	Kiangunu Mixed Secondary	Sub-County
79	Njahi Mixed Secondary	Sub-County
80	Mbichi Mixed Secondary	Sub-County
81	Kamwirigi Mixed Secondary	Sub-County
82	Maria-ini Mixed Secondary	Sub-County
83	PCEA Mukuyu-ini Mixed Secondary	Sub-County
84	Kiabere Mixed Secondary	Sub-County
85	Iruri Mixed Secondary	Sub-County
86	Karuri Mixed Secondary	Sub-County
87	Gacharage Mixed Secondary	Sub-County
88	Cianda Mixed Secondary	Sub-County
89	Thimbigua Mixed Secondary	Sub-County
90	Kiambaa Mixed Secondary	Sub-County
91	Kanyariri Mixed Secondary	Sub-County
92	Kibichiku Mixed Secondary	Sub-County
93	Rungiri Mixed Secondary	Sub-County