DETERMINANTS INFLUENCING THE INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN PHYSICS INSTRUCTION IN SECONDARY SCHOOLS WITHIN NAIROBI COUNTY, KENYA

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Doctorate of Education (EdD)

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Abstract

DETERMINANTS INFLUENCING THE INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN PHYSICS INSTRUCTION IN SECONDARY SCHOOLS WITHIN NAIROBI COUNTY, KENYA

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The rapid advancement of Communication Technologies (CTs) has transformed physics education by shifting instruction from teacher-centred approaches to learner-centred models that actively engage students in developing scientific competencies. Despite these benefits, physics enrolment and performance in Nairobi County, Kenya, have continued to decline. The report from the Ministry of Education in Kenya between 2018 and 2020 depicts that student registration for physics examinations dropped from 2,023 to 1,345, while the mean score dropped from 5.67 to 4.06. This decline has been linked to continued reliance on traditional teaching methods and limited integration of communication technologies in physics instruction. Although Kenya has established policies to promote technology integration in education, adoption remains low. ICT utilization in physics instruction is below 20%, compared to over 50% in sectors such as telecommunications, finance and manufacturing. The study therefore investigated constraints influencing the integration of Communication Technologies in physics instruction in secondary schools in Nairobi County. It examined ICT resource availability, ICT-integrated strategies and the influence of teachers' and students' attitudes on technology use. The study employed a mixed-method research design using convergent triangulation. The target population comprised 921 participants, including 76 principals, 92 physics teachers, and 753 physics students. A sample of 305 participants was selected, consisting of 25 principals, 30 physics teachers, and 250 Form Three physics students. Data were collected using the Physics Teachers Questionnaire, Physics Students Questionnaire, and Principals Interview Schedule. Quantitative data were analysed using descriptive and inferential statistics, while qualitative data were coded and analysed thematically. The findings revealed that majority of the schools lacked essential ICT resources, including scanners, teleconferencing facilities, KICD digital content, and school-developed instructional materials. Where ICT resources existed, they were mainly used for administrative purposes rather than teaching. Physics teachers predominantly relied on discussion, explanation, lectures, and demonstrations. ICT-based strategies such as simulations, animations, virtual experiments, and digital demonstrations were rarely used despite their potential to support authentic learning, experiential engagement, and knowledge construction. The study concluded that *inadequate ICT resources, limited ICT-integrated pedagogies, and attitudinal factors* hinder effective implementation. It recommends increased investment in ICT infrastructure, teacher professional development, and monitoring and evaluation to strengthen technology integration in physics education across Kenyan schools.

Declaration

"I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own".

AI Acknowledgment

I admit that I have used Grammarly (https://grammarly.com) to proofread chapter 4 of my thesis. The action was completed on 22.03.2025. The prompts applied were Proofread and corrected the grammar of the following text.

Copyright Page

Dedication

I dedicate this dissertation to my loving family for their unwavering support, encouragement, patience, and sacrifices throughout my academic journey. To my beloved parents, whose moral support, wisdom, love, and encouragement inspired me to persevere and pursue my academic aspirations, I remain eternally grateful. To my dear wife, whose unwavering love, understanding, and steadfast belief in me sustained me through the most challenging moments, I offer my deepest appreciation. Finally, I dedicate this work to my supervisors and course mates for their invaluable guidance, constructive feedback, encouragement, and intellectual support, which greatly contributed to my academic growth and development.

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May the Almighty God bless you.

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List of Abbreviations

AI	Artificial Intelligence
APS	American Physical Society
AR	Augmented Reality
ASD	Autism Spectrum Disorder
AUT	Actual usage of Technology
CAI	Computer-Assisted Instruction
CBC	Competency-Based Curriculum
CBE	Curriculum-Based Establishment
CEMASTEA	Centre for Mathematics, Science and Technology in East Africa
COVID-19	Coronavirus Disease-19
DLP	Digital Literacy Program
ESP	Economic Stimulus Program
Gen Z	Generation Z
ICT	Information and Communication Technology
IoP	Institute of Physics
IoT	Internet of Things
IT	Information Technology
KBC	Kenya Broadcasting Corporation
KICD	Kenya Institute of Curriculum Development
KNBS	Kenya National Bureau of Statistics
KNEC	Kenya National Examinations Council
LMS	Learning Management System
ML	Machine language

MoE	Ministry of Education
MOOCs	Massive Open Online Courses
NACOSTI	National Commission for Science, Technology and Innovation
OECD	Organisation for Economic Co-operation and Development
PIS	Principal Interview Schedule
PHET	Physics Education Technology
PSQ	Physics Student Questionnaire
PTQ	Physics Teacher Questionnaire
SPSS	Statistical Package for Social Sciences
STEM	Science, Technology, Engineering, and Mathematics
TPACK	Technological Pedagogical and Content Knowledge
TSC	Teachers Service Commission
TTC	Teachers Training College
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UREC	UNICAF Research Ethics Committee
USA	United States of America
VR	Virtual Reality
WWW	World Wide Web

CHAPTER ONE: INTRODUCTION

1.0 Introduction

The introduction of Communication Technologies has significantly transformed instruction process in the world since the 19^{th} century. The education systems across the world have shifted towards competency-based, equitable, and more inclusive to marginalised and disadvantaged children in society. The usage of technology has empowered teachers to use more advanced technological tools to allow learners access to quality education. However, due to inadequate infrastructure and experience among the educators, the employment of technological tools in education has been minimal, especially in third-world countries like Kenya. As education has become more internalised and globalised, there has been a notable change in the way technology is being incorporated into the instructional process (Computer, 2023). As stated in the promulgation of the 2010 Kenyan Constitution, the ICT laws of the Kenyan government created a fundamental framework for the development of ICT institutions in the country to expedite its adoption in education.

As a critical science, physics is essential to students' growth in problem-solving and for development of logical reasoning skills. The absence of qualified teachers, restricted access to laboratory equipment, and a general lack of student engagement because of abstract physics concepts have long been obstacles to effective physics instruction in Kenya. Nonetheless, a promising approach to resolving these problems is the growing accessibility and the adaption of communication technologies in the field of education. The application of technological devices in the process of teaching physics in Kenya has gained significance in enhancing the value of the instructional process. Amalgamation of technology into the classroom is a booming topic that the country embraces with the Competency-Based Education (CBE) and is still investing in digital infrastructure.

The new perspectives that digital tools, such as simulations, interactive applications, virtual laboratories, and online courses, offers interactive resources to the teaching of physics that can assist in making physics, a subject that many students believe to be abstract and challenging to learn, exciting, helpful, and more approachable. Kurniywan (2014) believed that the technologies can be applied to close the gap between the abstract ideas and the real-life processes in order to allow students to observe complex processes and perform experiments under the conditions of insufficiency of resources. However, despite the existence of these disadvantages as well, such as inadequate access to the net, deficiency of ICT equipment in the schools within the rural areas, and lack of tutor training in the field, Kenya has slowly taken a step towards the introduction of technology to the teaching of physics, thus ensuring a better quality of the knowledge that is acquired and offering a glimpse into the production of scientists and engineers on a large scale. The introduction of the usage of technological devices in the physics instruction process is changing the way learners will engage with the lifelong content and the way the teacher will deliver a lesson during teaching and evaluation process. The conceptual knowledge can be supported by the use of digital simulations, virtual laboratories, interactive whiteboards, and web resources, enabling students to visualize and manipulate the physical phenomena, which is not possible in real-life classrooms. They can be given an example of a simulation, such as a dangerous, expensive, or logistically difficult physics experiment such as production of X-rays that can be simulated in schools.

The education stakeholders in the government, have also been sensitized on the importance of integration of educational technology in education, especially in the effective implementation of Competency Based Education (CBE). Wambua (2018) asserts that programs like the Digital Literacy Programme (DLP) have been used to facilitate the provision of digital equipment to the schools and teacher educators to enable them to incorporate ICT in their instruction procedures. Such programs are slowly transforming the environment to be more receptive to technology, so that even as the short-term deficiencies in infrastructural and digital literacy remain a major challenge, particularly in underserved regions as well as rural areas. In addition to that, the COVID-19 pandemic crisis predetermined the need to resort to remote and online learning systems, which compelled schools to become more active in considering the use of virtual tools. This change brought about old disparities according to Fajoyegbe et al. (2024) and the need to shift to the current technological applications that could facilitate lifelong learning of physics education. Overall, technology use in the instruction of physics in Kenya is an emerging issue that has significant potential in helping learners to achieve the education goals. The usage of various technological resources in education provides immediate feedback to the previous problems in order to make physics simple and utilize it as an interactive and appealing subject for the students.

The incorporation of technological tools in the education field is a vital component of physics instruction and it also gaining momentum in the future since the country is moving towards building digital base and the capacity of the teachers to respond to the demands of 21st century. Vision 2030 and the Big Four agenda legislation policies have set the benchmark for quality education and provide a significant solution to people in the sector of affordable housing, quality healthcare and industrialization, which is the Kenyan government's strategic agenda. Kenya’s Vision 2030 seeks to build a high-quality education, training, and research system that can equip citizens with the knowledge and skills needed for a competitive global economy. The strategy on technology integration in education is designed to support the country’s transition into a modern, industrialized, and middle-income knowledge-based society (Badmus, 2026). It also emphasizes reducing the skills mismatch, promoting digital literacy, and ensuring that all learners have fair and equal access to education opportunities. To realize this, the government developed the Bottom-Up Economic Transformation Agenda (BETA), targeting the promotion of small and medium-sized enterprises, agriculture, affordable housing, healthcare, and digital transformation towards the attainment of balanced economic development on economic issues. The application of technology into the instruction process of the physics has helped in building up the major competencies that are present amongst the learners, and these are problem-solving, teamwork, critical thinking, and effective communication. The science teachers have, however, been the first teachers to adopt the use of technology, contrary to their colleagues in other technical and human subjects like physics, which are critical in facilitating scientific innovation. The employment of ICTs in teaching physics in high schools within Kenya is therefore, required in the development of competency-based skills of digital literacy among the students.

A study conducted by the Hanover Research Organization (Zhu and Wang, 2026) found that instructional technology was very important to college students in the United States, and it enriched their comprehension of abstract scientific topics. Therefore, it is important to incorporate technology in the instruction of physics in Kenya to motivate learners towards physics instruction. Simpson (2015) noted that the incorporation of technology in physics education inspires students by amalgamating complex concepts and visualising hazardous physics experiments via simulation. However, the majority of the Kenyan secondary schools have an inadequate access of technology learning devices for the purpose of instruction. This inquiry amid to identify the constraints to the applicable ICT incorporation in physics instruction. Educational studies such as Hughes (2016) depicted that at least 20% of secondary schools in the Republic of Kenya have utilized communication technologies in the instructional process.

The constraints to technological integration in education are negative attitudes towards technology use by the teachers, lack of administrative support, certain policies to implement implementation of ICT, absence of ICT infrastructure, and lack of goodwill of the governments due to a lack of resources. Further, it was noted that the limiting variables to ICT utilization in education comprised of those that have been compiled by the Ministry of Education in Nigeria in the intensive literature review that uncovered that ineffective application of technology in learning is caused by the indifferent attitude of the students and the teachers, inadequate of ICT facilities, negative attitude of the teachers or students and power outages (Osodo, 2017). However, despite the massive investment in the procurement of ICT resources, there is no significant academic improvement being experienced in the schools. ICT integration in physics education at the secondary school level has the opportunity to bring change in teaching methodologies, learner participation and knowledge outcomes. The Government of Kenya has put emphasis on the concept of ICT in education as very important, as has been witnessed through a number of policies and legislation initiatives that have been put in place aimed at modernizing the education structure.

However, despite this legislation on ICT incorporation in education, the application of ICT in the physics lessons within Nairobi County remains minimal among the secondary school teachers. One of the studies by UNESCO (2021) about the report on Global Education: Digital Divide Education Monitoring established that in certain schools that are under the jurisdiction of Nairobi County, the proper ICT equipment and facilities are not completely installed in the institutions, and therefore, meeting the high demand of the learners is a challenge. The absence of technology integration is generally attributed to a shortage of finances due budget constraints, which prevents the acquisition of the most recent software and electronic education resources. Moreover, the investigation also established that a significant proportion of the schools were not online, and this was because of the high costs they incurred in the process of creating and maintaining the connection on the internet.

The training and retooling of the 21st century teachers are very important for effective implementation of Competency Based Education. Focusing on the investigation undertaken by Mwambela et al. (2020), it was noted that despite some teachers having a positive attitude to utilize ICT tools in their teaching, a considerable proportion of them had no skills and training to allow them to efficiently integrate technological devices in their educational programs. The inspection of the secondary schools in Tigania West in Meru County showed that 56.57 percent of teachers were not proficient in technology, and the instructors who received training perceived that they possessed no competencies required to impart ICT with efficiency (Gikundi, 2016). This equates to poor use of the available ICT resources in schools due to insufficient training.

The support and the institutional regulations also come into play as far as communication technology integration in education is related. In some of these cases, the school administration restricts the use of ICT, which narrows access to the necessary tools that the instructors require. The incorporation of technology into the curriculum is worsened by the fact that there are no clear policies and strategic plans for the introduction of ICT integration. The inquiry by Njuguna, et al. (2025) on the topic of factors influencing the "*integration of information, communication, and technology in teaching and learning in public secondary schools in Kinangop Sub-county, Nyandarua County, Kenya"*, pointed out the necessity to have effective school-level policies that would allow the use of computers and allow the continuous programs of professional training by the teachers. Besides this, technical barriers also exist that thwart the use of technical devices in learning, such as power outages and the lack of technical support staff. Educators are willing to make usage of technology in schooling because of effective electricity and timely technical support. The complex of the infrastructural issues and the above-mentioned variables create a complex environment, and the correct implementation of the ICT physics teaching seems to be impossible.

Mwambela et al. (2020) propose in their study that a significant percentage of physics teachers use the application of ICT during their practicum compared to the non-users of ICT, and this means that the government project of training teachers on how to customize ICT in teaching is yielding impressive outcomes. The study also established that the type of schooling, be it a public school or a privately run school, did not affect the usage of technology tools in science instruction in Mombasa County, although there was a perception that privately managed secondary schools had better ICT facilities and used technology more to teach the science subject as compared to the government secondary schools. By using Information and Communication Technologies in education helps students learn better by making lessons more engaging, adapting to each learners needs, and providing access to many digital resources. ICT also makes traditional teaching more interactive and supports different ways of learning.

Mwambela et al.'s (2020) article also concluded that there is minimal application of ICT in learning sciences as indicated in most high schools in Mombasa County in Kenya. The issues that have been experienced in the process of teaching physics with ICT materials in learning institutions in the Mombasa region encompass inadequate ICT facilities, the incapacity of physics teachers to utilize ICT to instruct learners, and the limited time for preparation of the lesson material in the heavy workload of physics teachers, especially in a large number of schools. Asserting the fact that there is a probability of ICT facilitating a better teaching process in physics, the barriers to its use must be known and reduced. This thesis attempts to examine the constraints that limit the usage communication technologies in the physics instruction among the students in Kenya. The combination of technology and other learning resources like the physics laboratory or availability of lab technician is guided by policy and practice interventions in facilitating the smooth process of enhancing the learning outcomes.

1.1 Statement of the Problem

The integration of technologies in education could be used to enrich and enhance the learning process of physics, but this is barely a component of the learning process, especially at the secondary level in Kenya. Such systematic impediments that include infrastructural facilities, inadequate teacher retooling in the application of various technological devices in the instruction of physics and a deficiency of access to technology services are significant in the real implementation of technology in instruction. Even though the application of ICTs in educational policies and curriculum development has been advocated further to enhance the learning objectives of schooling, a significant proportion of the physics teachers and students in majority of schools are grappling with trials that deter the proper application of communication technologies. The specific subject performance of students in physics is dependent on the instructional methods used by teachers, learning resources and interest of the learner.

The Ministry of Education (2020) report established a decline in the mean performance in the Physics subject in Kenya, as indicated in Table 1. This was noted in the results of the "Kenya Certificate of Secondary Education (KCSE)" at the high school level of which learners are graded using alphabetical letters from Grade A to E, such that Grade A denotes a mean score of 12 points, while Grade E denotes a mean score of 1 point (MoE, 2022). The deterioration in physics mean performance was attributed to insufficient instructional resources, ineffective teaching methodologies, and a deficiency of trained professionals in the majority of secondary schools. Physics is one of the sciences that has had a decreasing enrolment and performance in secondary schools in Kenya, as shown in Table 1. The student enrolment and performance are contingent upon their opinion that Physics is challenging and unengaging due to its abstract nature. Educational studies show that the inclusion of ICTs in physics education can help simplify abstract concepts, motivate students, and eventually improve the quality of education, as noted by Erdem (2019). To achieve this potential, physics teachers need to have technological skills on how to infuse technology in the learning of physics at secondary level. Table 1 shows the population of physics students who sat for the KCSE examination between 2018 and 2020 and the average score performance out of possible points of 12.

Table 1

Mean Score of Physics Candidates who sat for the KCSE Examination in Nairobi County from 2018 to 2020

Year	Number of Physics Candidates Sat for KCSE Examination	Mean Score performance $\left({}^{x}/_{12}\right)$
2018	2023	5.67
2019	1763	4.78
2020	1345	4.06

Source: *Adopted from Nairobi County Office of the Ministry of Education in Kenya (2021)*

From Table 1, it was realized that the population size of the physics students in Nairobi County has decreased to 1,345 in 2020, negatively affecting the attainment of education goals such as access to compulsory quality education as enshrined in the Constitution of Kenya (2010). The decrease in the number of candidates, along with the average performance, is observable over the specified period of the three years. Almost 33.5 percent of physics candidates between the period of 2018 to 2020 dropped out, and 1,345 candidates had a mean score of 4.06 in 2018 to 2020. The high rate of drop out of physics students could be attributed to the complexity of training and learning physics at the senior school that is closely associated with the incompetent usage of technology to enhance mastery of physics content among learners. According to CEMASTEA (2022) and UNESCO (2022), the accessibility of ICT tools, insufficient teacher education, and infrastructure negatively impact the standard of science teaching that negatively influence the student interest and performance in physics.

The study points to the need to investigate and address the variables that influence the usage of communication devices in the instruction of physics in Kenya to increase the involvement of the students and their achievement and reverse the decreasing tendencies in student enrollment. The education policymakers tried to solve this problem by identifying pertinent issues affecting the physics teachers and students, such as the lack of laboratories, ineffective teaching techniques, inadequate training of the personnel and lack of motivation to study physics as a science at senior school. According to the report provided by the Ministry of Education in Kenya (MoE, 2020), the performance of learning institutions where tutors teaching physics are equipped with ICT devices are much better in achieving the learning outcomes than those that do not have. It was noted that the mean of physics was greater than 5.0 out of possible 12 points in schools where physics teachers used ICT in their instruction process. Of the total population of teachers in the country, less than 10 percent of teachers in classrooms apply ICT resources in classroom instruction. The objective to use ICT for physics practical lessons to improve the interactivity, engagement, and accessibility of teaching physics among learners is not achieving its maximum potential. This necessitates the identification and systematic analysis of the determinants that influence the usage of Communication Technology (CT) in instruction of physics in Kenya.

Notwithstanding, examining the initiatives taken by both the national and international partners to incorporate ICT in education, there is minimal usage of communication technologies in the instruction of physics in secondary schools within Nairobi County in Kenya. However, despite of the measures taken by the Kenyan government, such as implementation of Literacy programme of digital devices and the National policy on ICT, to streamline technology integration in schools, research have shown that the use of technology in science and specifically physics, is extremely low (MoE, 2022). The distribution of ICT resources in Nairobi county shows significant statistical inequalities such that one-third of the secondary schools have functional computer laboratories (Abedi, 2024), and less than 20% of them are connected to the internet regularly (CEMASTEA, 2022).

According to a survey conducted by Abedi (2024), over sixty-five percent of physics teachers rarely used ICT materials in their lessons, and the reasons were diverse and ranged from the absence of training to the insufficiency of facilities and the lack of support from the administration. In the recent research by the KICD, it was discovered that among teachers of physics, only 28 percent of tutors in the county acknowledged special training on the ICT integration, which is specifically designed to teach the science subject (KICD, 2022). Furthermore, the fact that the public and private organizations fail to agree on certain matters only extrapolates the problem of ICT integration in education. Surprisingly, the report by UNESCO (2022) indicated that the county of Nairobi has more modern ICT facilities in private schools as opposed to the public schools. It is this gap that denies the students in underfunded schools' equitable access to good physics education. It also presents a notion of the specific issues and pressures that prevail in the ICT incorporation in education in the same environment.

These discrepancies with the data on ICT usage in secondary schools implies that there is an underlying problem with using ICT and its effective application in the learning of physics to improve the subject performance of the physics students. The ICT tools will not offer a solution in physics learning and engagement without the remedy of the problems in the domain of infrastructural, pedagogical and policy-related education. The analysis and evaluation of the study involved the key constraints that limit the usage of communication technologies in physics teaching at secondary level with the view of providing recommendations to the education stakeholders, on how effectively ICT could be integrated into physics instruction.

1.2 Purpose of the Study, Research Aims and Objectives

The general rationale of this study was to investigate the determinants influencing the inclusion of Information Technology (IT) in physics instruction in Secondary Schools of Nairobi County in Kenya. Further, the inquiry has also examined the barriers to effective usage of communication technology in the instruction process of physics at the high school level. The inquiry was based on the administration and the socio-cultural conditions that teachers face in the learning institutions, the infrastructural learning institutions and ICT-integrated strategies. The outcomes of this inquiry could be applied to policymaking in education, viable interventions that may be implemented to enhance the usage of communication technologies in the instruction of physics as one of the elements of the overall education process in Kenya in digital integration. The study considered the infrastructural inadequacies, and it was not confined to the accessibility of the ICT hardware, the internet, and electricity in high schools.

Secondly, an analysis of teacher-related factors that include ICT literacy levels, training needs, attitudes and readiness to use ICT in Physics education was conducted. The study evaluated institutional and administrative obstacles, including educational policy, leadership endorsement, and access to technical assistance as factors hindering the effective inclusion of communication technology in physics instruction. Further, the study assessed the students' accessibility and involvement with ICT technologies within the framework of Physics education. Lastly, the study offers suggestions to educational stakeholders on enhancing IT integration in Physics instruction to improve student achievements and engagement in the subject content. The study was guided by the following key research objectives:

1. To identify the types of ICT resources that are accessible and utilized for the physics teachers during instruction in Nairobi County.
2. To examine the ICT-integrated instructional strategies that are employed by Physics teachers in secondary schools in Nairobi County.
3. To examine how the attitude of physics teachers influences the integration of ICT in Physics instruction in Nairobi County.
4. To determine the extent to which the attitude of Physics students affect the effective utilization of ICT in Physics instruction in Nairobi County.

1.3 Nature and Significance of the Study

The target region for the investigation was in Nairobi County, Kenya, which is an urban setting with most of the secondary schools assumed to have been equipped with ICT learning materials and infrastructural resources. Educational studies in Nairobi County indicate that despite widespread ICT awareness, classroom integration is hindered by factors such as inadequate net access, limited equipment, heavy teacher workload, restrictive policies, and inadequate teacher training in ICT pedagogy (Kirui, 2011). The study examines the constraints to successful usage of communication technologies in Physics instruction in learning institutions in Kenya. The factors included infrastructural issues, teacher and learners' attitudes, access to resources, and administrative support. The rationale for this study is to help the physics teachers and policy makers to understand the systemic and contextual factors influencing communication technology integration in Physics instruction. As highlighted earlier, the findings of this study are beneficial to policymakers, school administrators, Heads of the physics department, curriculum developers, and tutor's teacher training institutions to develop targeted interventions to improve ICT utilisation, enhance Physics instruction, and boost student engagement and performance. This study examines at what helps or hinders the use of technology (ICT) in physics instruction such that the findings will help Policymakers get evidence to improve technology policies and educational programs like the Digital Literacy Programme, so that schools in the country have requisite ICT tools. School administrators or principals will learn how to better support teachers with technology resources, training, and a positive environment for using technology in classroom lessons. Heads of Physics Departments gain insights on how to help their teachers overcome challenges and share best international practices for using tech in classes. Curriculum developers will gain more information on how to update Physics curricula to include useful digital tools and make learning more relevant for the 21st century students. Tutors in the teacher training institutions and universities will receive guidance on how to train future teachers so they're ready and confident to use technology when teaching Physics. Therefore, the study aims to make Physics lessons more engaging and effective by helping everyone involved make the best use of the available technology Further, the study contributes to the dialogue on digital revolution in education and the connection between educational policy and classroom implementation in Kenya. According to the report by the Ministry of Education, it was noted that a third of the secondary schools in Nairobi County benefited from the Economic Stimulus Program (ESP) on the provision of ICT-related resources, and therefore, it was assumed that a noteworthy proportion of the physics teachers and students were computer literate as compared to other counties in Kenya (Kisirkoi, 2015). To effectively tackle the persistent challenges facing the Physics education in Nairobi County and specifically low student enrollment and poor KCSE results, this study investigates the use of ICT in classrooms. Of great importance is that technology helps to make tough physics topics easier to understand, encourages active, student-focused learning and improve performance.

The study primarily examined the influences behind the underutilisation of technology tools such as projectors, computers and simulations in physics instruction within secondary schools in Nairobi county. The investigation was guided with objectives examining pragmatic obstacles to ICT integration such as limited infrastructure, teacher training, physics teachers and learners' perceptions, curricular limitations, and administrative support. The inquiry utilized a mixed-method research design of collecting data using questionnaires of Physics teachers and students as well as interviewing the school principals. The use of a mixed- method research design was to integrate numerical findings that gave more detailed explanations from multiple data sources that include the physics teachers and students. The principals also provided a more robust from administrative and policy perspective about ICT integration in schools. In the context and background, the study expounds on the research conducted in Kenyan counties, such as Mombasa and Murang`a, where the investigators have examined obstacles hindering the amalgamation of technology in education to improve the instruction outcomes.

The town of Nairobi has distinctive dynamics of being the capital city of Kenya, with considerable access to technology, juxtaposed with severe disparities in educational resources and personnel capabilities. Nairobi County has an estimated population of 5 million people with over 3million learners in school. The approximate area of Nairobi is 696.1m^2 with a poverty rate of 1.3%. The dropout rate at the secondary school level in the county is 6.1% while Nyamira County has the highest dropout rate of 8.2% against the national dropout rate of 5.8% (KNBS, 2019). The study employed a quantitative approach that involved the use of semi-structured items in the tools in assessing ICT availability, usage frequency, training levels, and teachers' and learners’ attitudes. A qualitative approach that encompassed the usage of semi-structured interviews to elucidate policy and cultural or systemic limitations from the school principals was also utilised. The numerical data were analysed using both inferential and descriptive statistical analysis, while the non-numerical data were analysed thematically and discussed coherently with quantitative findings to ascertain the root causes of determinants constraining the integration of communication technologies in physics instruction in learning institutions in Kenya. It was hoped that the study offered pragmatic significance in the identification of the obstacles limiting the use of technology, which included shortages of ICT tools, unreliable internet, and inadequate teacher preparedness that impede the utilisation of ICT in Physics education. The study provided valuable information that will assist educational stakeholders, teachers, administrators, and policy makers in identifying optimal investment areas for developing effective ICT-enhanced physics instruction.

In regard to the concept of establishing scholarly contribution, the study has bridged a gap in geographical coverage of the current literature that has concentrated on the counties of Mombasa and Murang'a. In addition, this study included in the overall literature in the field of ICT in physics, which supplements the literature reviews that substantiate the models of learner-centeredness and the necessity to develop the capacity of teachers. On the policy and curriculum interventions implications, the Kenyan ICT integration policy is determined by the results of this study and can be used in modifying the approaches in the urban counties with a wide range of resources. Moreover, the findings may be utilized to form the school-wide policy regarding the ICT integration, including the flexibility of the process of scheduling, the regulation of the use of the internet, and the training of the teachers regarding the pedagogies and being aware of the technologies. The enactment of Competency-Based Curriculum (CBC) that is centred on the 21st-century competencies and urgency that is placed on the proficient development of teachers in the usage of communication technologies could be effectively achieved through the assistance of the Ministry of Education in Kenya. According to the learning outcomes, the inquiry can be compared to the rest of the studies in the world that presupposes the idea that ICT-enhanced teaching in physics enhances the conceptual knowledge and acquisition among the learners.

The significance of this study is to assist educational institutions in optimising returns on investments in ICT infrastructure by guaranteeing the meaningful application of technology in educational classrooms. In Summary, the study focused on examining the real-world constraints to both technical and human aspects that hinder secondary school physics teachers in Nairobi County from completely integrating ICT in education. This is important as it provides localised evidence to support broader conclusions, presents clear, context-specific suggestions for educational policy and practice, and ultimately aims to improve student progress in a crucial STEM topic through enhanced technology utilisation. Lastly, the findings of this study would be more important to learners in building their self-esteem and interests in physics instruction, hence developing their 21st-century skills and competencies.

1.4 Research Questions

1. What types of ICT resources are accessible and utilized for the purpose of physics instruction in Nairobi County?
2. Which ICT-integrated instructional strategies are employed by Physics teachers in secondary schools in Nairobi County?
3. How does the attitude of Physics teachers influence the integration of ICT in Physics instruction in Nairobi County?
4. To what extent does the attitude of Physics students affect the effective utilization of ICT in Physics instruction in secondary schools in Nairobi County?

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction to the Literature Review

A literature re-examination is a critical study of the conceptual and theoretical knowledge that is relevant in the specific area of study. According to Snyder (2019) and Creswell (2023), they defined literature review as a critical and organized summary of both published and unpublished academic work related on a specific research topic. Therefore, its purpose is to show what is already known, highlight gaps in the study, and provide an empirical foundation of the study. Sparbel and Anderson (2000) noted that literature review is an overview of both the conceptual and theoretical research activities. The critical literature review in the chapter was about the application of technological devices in teaching physics and how it focuses on hypothetical and conceptual structures. This study adopted literature review that critically summarized the theoretical framework on ICT application in physics instruction, the history of communication technologies in Education and the application of ICT in industry and evaluated the low rate of espousal of communication technologies in the physics curriculum in Kenya. Further, this section also addressed the interactive technologies that have been utilized in teaching physics to inculcate 21st-century skills among the students using the element of authentic learning as facilitated by the physics teachers.

2.1 Theoretical Framework

The study was anchored on numerous educational theories that offered a solid foundation on which the success of integrating Communication Technologies (CT) in the pedagogy of physics would be evaluated. The educational theories included behaviourism, cognitivism, cognitivism and social constructivism. All these theories had a different role without comparing them, and they described the way that the students learn and how ICT can be applied to improve the understanding of the content of physics. One more model that has made its mark in the comprehension of the correlation of the several kinds of information in the classroom and how technology can help in the procedure of teaching is the Technological Pedagogical and Content Knowledge (TPACK) model that was established by Mishra and Koehler (2006). Further, this section elaborated on the application of theories in education and how they are implemented in the procedure of technology integration in instruction and how they inform the learning process.

2.1.1 Behaviourism Theory

The theory of behaviourism evolved by such psychologist researchers as Edward Thorndike, Ivan Pavlov, and B.F. Skinner. Behaviourism presupposes that learning takes place in response to the interplay between the people and the environment and that the conditions of action are conditioned differently as described by Skinner and Pritchard, (1953). Behaviourists think that learning is an outcome of the stimuli and repetitions of responses, and reinforcement plays a role in altering human nature. The behaviourist mode lacks much consideration for mental processes but focuses on the observable behaviour that is perceived to be a sign of learning. The theory implies that the learners of age group between 14 to 18 years receive the new knowledge in accordance with operant conditioning, in which the reaction to the stimulus is acquired by means of reinforcement. The study by Anwar et al., (2024) on the "*Application of behaviourist theory in classroom instructional reforms*" explain that since the learners are rewarded as a result of the behaviour they are doing, there are high chances that they will repeat the behaviour, therefore systematically learning and gaining knowledge of the concepts.

Regarding the use of technological tools in education, the Behaviourism theory can be applied to the way learners interact with digital tools and digital platforms at secondary level in the Kenyan context. Bervell (2025) in his study titled "*Behavioural intentions toward information communication technology integration in secondary education*" affirmed that learning is a mechanical process of linking stimuli with responses, resulting in the emergence of new behaviours among the learners. The attitude of physics students directly influences behavioural intention on the use of technological tools for the learning process. Indicatively, physics learners who are taken through an educational application that gives them instant feedback on right answers will become more driven to learn further as opposed to those presented with course books only. Buhamad (2024) affirmed that positive reinforcement, or the use of rewards like badges or points, helps motivate the students to work through the material and remain motivated throughout the learning process. For instance, in the Kenyan context, if physics students could visualise the operation of the X-ray tubes and observe on the screen how X-rays are produced, then they will be able to effectively understand the abstract concept. This enhances the understanding and comprehension of the production of X-rays as opposed to just learning theoretically. Each new concept learned through ICT becomes a motivational factor for mastering subsequent concepts. This creates a cumulative learning process where students are encouraged to progress through increasingly complex concepts.

According to Kabir, (2026) cited from the study by Buxkemper and Hartfiel (2003), learning is very dynamic and is a very complex process that is much more elaborate than behaviourism implies. Further Kabir (2026) noted that although behaviourists might have criticized the theory on the basis of simplifying the learning process because they are not able to account for the mental activities, they have affirmed that the model can still be applied practically in the classroom. The teachers will prepare the lessons on the ICT part, and they will involve repetitions and positive reinforcements to enable the students to learn the important principles in physics. One such example is to take students through the repetition of simulation of experiments in physics and let the students know the result of the simulation after each attempt until the principles being taught are well understood. The reason behind this is that the technology will enable the students to correct the errors and reenact the right behaviours, and this is because they will recall and grasp the subject matter better.

Besides that, ICT applications such as quiz games and gamification platforms would not appear to be alien to the ideas of behaviourism since according to the study conducted by Ochieng (2020) titled "*determinants constraining the use of communication technologies in learning institutions*", it was stated that ICT tools facilitate learning through providing instant feedback on what the student is saying, and hence, the learners can develop the relationship between what they are saying and the feedback. Such behaviourism can be regarded as a successful strategy of adopting the drill-and-practice methods of teaching physics. A case in point would be the fact that the software can be utilized to provide the students with instant feedback on their performance in solving the equations and to slowly develop their ability to solve problems by being exposed to them repeatedly.

Nevertheless, along with the good sides of behaviourism, there also exists the negative side of behaviourism. The opponents of the behaviourism theory decry that the theory fails to consider the inner process of thinking that is decisive in constructive learning, most especially in a subject like physics, where most of the focus is on critical thinking and problem solving. Consequently, the behaviourist techniques can be applicable in the construction of the basic levels of knowledge, and they might not be enough to promote additional education and practice the ideas. Therefore, behaviourists state learning as a mechanical process of association of a response and stimulus to elicit new behaviours among learners (Kabir, 2026). They also indicate that the bond has to be reinforced through practice; only with it will the recently learned behaviour be capable of being performed quickly and effectively, which will consequently make it a habit. This may happen as an indicator, where students are given a chance to type in physics notes using a computer keyboard, they can probably enhance their speed and productivity. In this regard, in order to learn how to apply ICT by applying a sufficient level of reinforcement and causing the learner to develop a response towards a neutral stimulus, this will necessitate a change in the learning behaviour.

The computer-assisted instruction (CAI) drill and practice software, automated testing and feedback, gamification and rewards are developed on the foundation of the behaviourist theory. The software of drill and practice offers practice on the physics concepts, which are presented with immediate feedback and support for the correct answers. The behaviourist learning methods are similar to the computer-assisted instruction programs that employ a progressive instructional methodology. The correct answers are reinforced by the immediate feedback that is devised by the automated testing and feedback. Rewards are given on the accomplishment of the correct question (they may be as a score, level, or badge), and this is directly associated with Skinner's concept of operant conditioning, where the consequences of the behaviour change the behaviour of the learner. The technologies assist the learners in internalizing physics concepts during the problem-solving processes.

2.1.2 Cognitivism Theory

Piaget (1971) introduced the cognitivist development theory, which examines brain-based learning and information processing by the mind. This theory deals with the internal process involved in learning that is reflected in the behaviours, unlike behaviourism, which deals with the observable behaviours and does not care what happens in the learner as propagated by Diyal and Malla (2025). The principles of cognitive learning are based on the fact that learners would internalize information by applying their senses, thoughts, and experience. Piaget (1971) also pointed out that learners develop new cognitive structures depending on the knowledge and world experiences that they already have, and this results in the development of their knowledge of the world.

Cognitive theory will be applied best in the situation where there is an ICT integration in education among learners at the secondary institution having ages between 14 to 18 years, as it assists in explaining how the technology can facilitate the psychological processes involved in learning. The application of the ICT tools, such as interactive simulation, visualization, and multimedia presentation, can be used to make the students understand the abstract physics topics in a more tangible way, not only through the working memory (short-term memory) but also through the long-term memory. According to cognitive theorists like Mayer (2021) and Machkour (2025) technology can be used to supplement the learning process by availing the content in alternative forms, and this means that the learner would digest and memorize the information in an efficient way. Technologies such as interactive simulations and adaptive learning systems help students to organise the physics concepts by activating the previous learnt content to be able to solve complex problems.

Metacognition is the ability to think about personal thinking, is one of the most important concepts of learning, which is cognitive according to Machkour, (2025). The learners may examine the way they process information or think via metacognitive practices, whereby the same will enable the learners to devise the means of their enhanced comprehension of the same. The mental tools, mind-mapping software, concept-mapping programs, and collaborative tools enable the learner to visualize the manner in which he/she thinks and the way he/she organizes the information in a better fashion, which could enable him/her to get more profound learning within the framework of the ICT. As an example, students studying physics at school level can apply the concept mapping software to the physics subject, which would apply the software to organize their knowledge on concepts like energy conservation or Newton's laws of motion in the same manner that the various concepts relate to each other as well.

The cognitive load theory and the information processing theory, which are closely related to the field of computer science, have transformed the way we think in relation to information processing and reception in learners. Sweller et al., (2020) and Sweller (1994) developed the cognitive load theory that elucidates the overloading of the working memory of the brain whenever it is overloaded with information. In this regard, ICT may be applied in easing the cognitive burden by subdividing more complex physics assignments into smaller complex assignments and permitting the students to process the information at their own pace.

Cognitive learning theory has also enabled teachers to seek the relationships between working and long-term memory, which have been correlated in the field of computer science with the application of technology. The human brain works similarly, just like the computer processes and stores information. Educational software and computer-assisted learning websites harness these cognitive principles and give a learner a chance of repetition and rehearsal of knowledge, which tends to be retained over time (Sweller et al., 2020). An example is given where physics students are able to learn through trial and error by using virtual laboratories to experiment on concepts like electric circuits or the theory of movement.

Other than that, the social learning theory coined by Bandura (1986) also demonstrates that learners learn 10 percent of what they learn in coursework and formal training, 20 percent in the development of relationships, and 70 percent in hard-fought experiences and practical. This observation supports the need to embrace ICT devices, which will support collaborative learning, i.e., students will be able to collaboratively solve problems and learn through the experience of their counterparts. ICT has offered the simplification of the concepts of physics by providing innumerable presentations of physics topics in the form of graphic representations, simulations, and interactive activities. It is repairing the common misconceptions by having factual information that is factual and acceptable. It also leads to personalized learning by ensuring the tailoring of the education to link the requirements and learning styles of the students, so that it is assured that the students will get engaged in physics subjects effectively.

The espousal of communication technologies (CT) in the study of physics has a firm foundation on the cognitivism paradigm that places so much emphasis on psychological activities in the education process. The learners can come up with the concepts of physics, which are abstract, and hence allow them to create mental pictures that otherwise would have been difficult to create out of text or other representation methods through the use of ICT tools like simulations and animation. ICT enhances information processing through the use of multimedia content and a two-way learning environment, which enhances better thought processes. One of the developments of cognitivism is cognitive load theory, which focuses on the importance of controlling the amount of information that should be processed at a time as noted by Sweller et al., (2020). The application of Communication technologies, like sequential lessons and guided inquiry software, can be used to solve complex physics problems.

Information Technology (IT) can be used to facilitate active learning, and this would encourage students to learn, which would be in collaboration with the cognitivist approach to learning, whereby the learners are not given information passively. The usage of Information Technology (IT) has led to high levels of learning since, at times, the conceptual change may be necessary in disciplines such as physics, whereby the learner is supposed to replace the misconception with scientifically proven concepts. Communication technology can assist adaptive learning systems and self-paced modules of study so that the learner can learn in his/her own time, reread what has already been learned, whether they need to or not, and also focus on areas where they are having problems, thus contributing to the cognitivist interpretation of individualized courses of learning.

ICT tools are used in cognitivist learning in reference to better handling of information, conceptualization, and thought. They help the students visualize such abstract concepts as the magnetism (electromagnetic) fields and the duality of waves and particles, which help the students in cognitive processing and understanding. The interactive circumstances of learning enable the learners to engage in playing with the variables, which enable the building of the concept and schemas. Scaffolding and guided instruction are also available using ICT tools, and they are both in agreement with the instructional events as pointed out in the Zone of Proximal Development (ZPD) proposed by Vygotsky, which are normally included in the cognitivist strategies (Wang, 2025). The tools assist the students in picturing the complex items and resolving the assignment to get a better grasp of the physics concepts.

2.1.3 Social Constructivism Theory

The popularized theory of social constructivism advanced by both Vygotsky (1978) and Piaget (1971) was that the learners are active participants in the construction of their own knowledge and that it is accomplished through interaction with the immediate environment. Social constructivism anticipates the learner to be an active participant in information building and not to passively receive the information. True to this perception, learning is a personal process that cannot be ignored because it is influenced by experience, knowledge, and interaction with other people. Rigopouli (2025) as narrated by Vygotsky (1978) on the "*Vygotsky's creativity options and ideas in 21st-century technology-enhanced learning*" mentioned the role of social setting that learners have that need to be considered such that their aggregation of efforts as well as through interaction with their peers and society is very important.

Social constructivists assume that learning is among those aspects that take place when learners between the ages of 14 to 18 years are provided with a chance to investigate, to experiment and to draw conclusions about the new information and the experiences in their lives. In addition, it is applied to physics education, for instance the learners are encouraged to complete practical activities, e.g., experiments and simulations, in which the learner can receive tests and build their own knowledge based on the real world experiences. Consoli et al., (2024) explained that use of ICT infrastructure such as virtual laboratories and simulation programs would help students to partake actively in the learning process by performing experiments in a virtual environment. This will allow them to build new knowledge by trial and error, contemplation, and cooperation with their peers.

Elliott et al. (2000) assert that learners form new knowledge through combining the new knowledge with the already familiar schemas. In learning physics, it may be a case where the learner is taught to use the new knowledge, say quantum mechanics or thermodynamics, on the familiar life circumstances or concepts previously learned by the student. In so doing, they form a more significant and acute interpretation of the subject. ICT may assist in this process, where they offer the learners a huge number of resources like multimedia presentations, interactive models, and online tutorials, which enable the learners to connect the theoretical and practical.

Vygotsky (1978) emphasized that "*zone of proximal development (ZPD) is the difference between what one person can perform without help and what he/she can perform with the help of another more learned person or instructor"*. The collaborative tools and peer-to-peer learning tools in the ICT-based setting facilitate the students working in groups and supporting each other in the learning process, hence filling the ZPD. One such example is that the students could be exposed to the projects in the content of physics by using the online discussion groups, group simulation, or web-based video conferencing tools, under which the students will have the ability to share their ideas, offer comments, and build knowledge together.

Social constructivism is also reputable in reflective learning (Syah, 2026) such that critical examination learners` experiences and what they have learned, they can learn at what point they have strayed and come up with a means of improving. ICT will allow using the e-portfolio and the digital journals to record the learning process of the students, which will outline their achievements during the course of the physics study. The ICT technologies enhance active learning in the aspects of offering interactive simulations and activities to survey the physics subjects among the students. They facilitate peer learning, whereby the students get to learn among themselves and enhance the knowledge they have.

Further, ICT can be used to connect physics and practice to help bring the subject closer and make it exciting for students. In the globalization era and an era of accelerated technological change, social constructivism revolves around the necessity to create a learning experience that is relevant to the 21st-century learner as noted by Chasokela (2025) and Gannar (2025). The teachers should be in a position to reflect on the inclusion of communication technologies to aid in collaboration, critical thinking, and solving problems in a science learning environment. The combination of the knowledge of ICT tools also makes it possible to create authentic learning experiences, which reflect the real-life challenges and provide the learners with the prospect to apply their competences in life to solve any emerging challenge.

The ICT tools are important in most of the components of the learning process, such as interactive simulation, collaborative systems, problem-based learning and inquiry learning, multimedia and hypermedia tools, student-generated content, and scaffolding and differentiation instructions. Interactive simulations and virtual laboratories give the student the opportunity to explore and discover the phenomenon of physics. The collaborative tools that would be utilized to support social constructivism are Google Classroom and discussion forums, where the students will be presented with an opportunity to co-create knowledge by interacting with peers. Chasokela (2025) affirmed that the problematic-oriented learning and inquiry-based education ones are the activities that are based on real-life problem simulation, for instance problems of projectile motion or energy conservation simulation. The students can learn at their own convenience, and this encourages non-linear learning patterns through the hypermedia and multimedia devices. ICT may similarly be employed to offer adaptive learning experiences (e.g., hints, tutorials, or step-by-step instructions) and can be adapted to the abilities of learning abilities of a particular learner, which successively raises the level of independence.

2.1.4 TPACK Model

Mishra and Koehler (2006) have come up with the invention of the Technological Pedagogical Content Knowledge (TPACK) model that deals with the interpretation of different forms of knowledge with the aim of promoting learning. Knowledge is divided into three categories by using the TPACK model, and this includes "*Technological Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK)" (*Mishra & Koehler, 2006*)*. The model establishes the communication between content, technology and pedagogy that forms the basis for effective integration of educational technology. The TPACK framework model helps enable the fact that special technical equipment (hardware and software) is utilized so that the acquired knowledge the students have on the subject of study may be improved. The three types of knowledge are redefined in diverse ways in the TPACK framework.

The relationships between the technological tools and educational activities are defined through the TPK. Pedagogical Content Knowledge (PCK) defines the methodological activities and specific subject objectives, whereas Technological Content Knowledge (TCK) explains the connections between technologies and the purposes to learn. Figure 1, shows the TPACK Model by Harris et al. (2009), indicates that the teaching technology must be interdependent with subject matter in learning.

Figure 1

The Simplified Model of TPACK

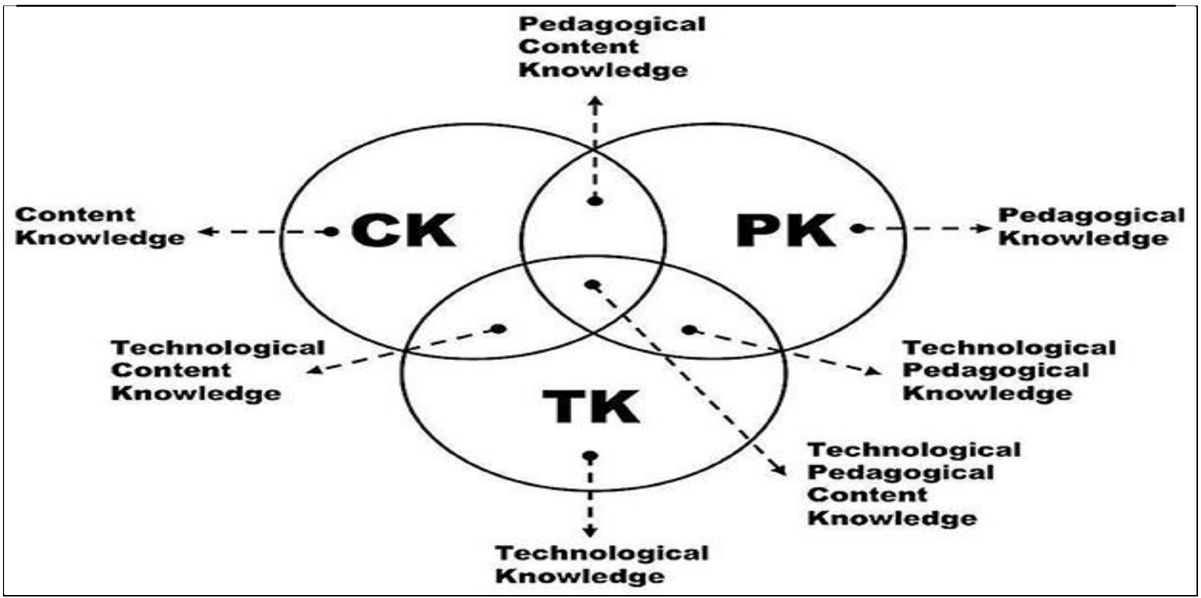


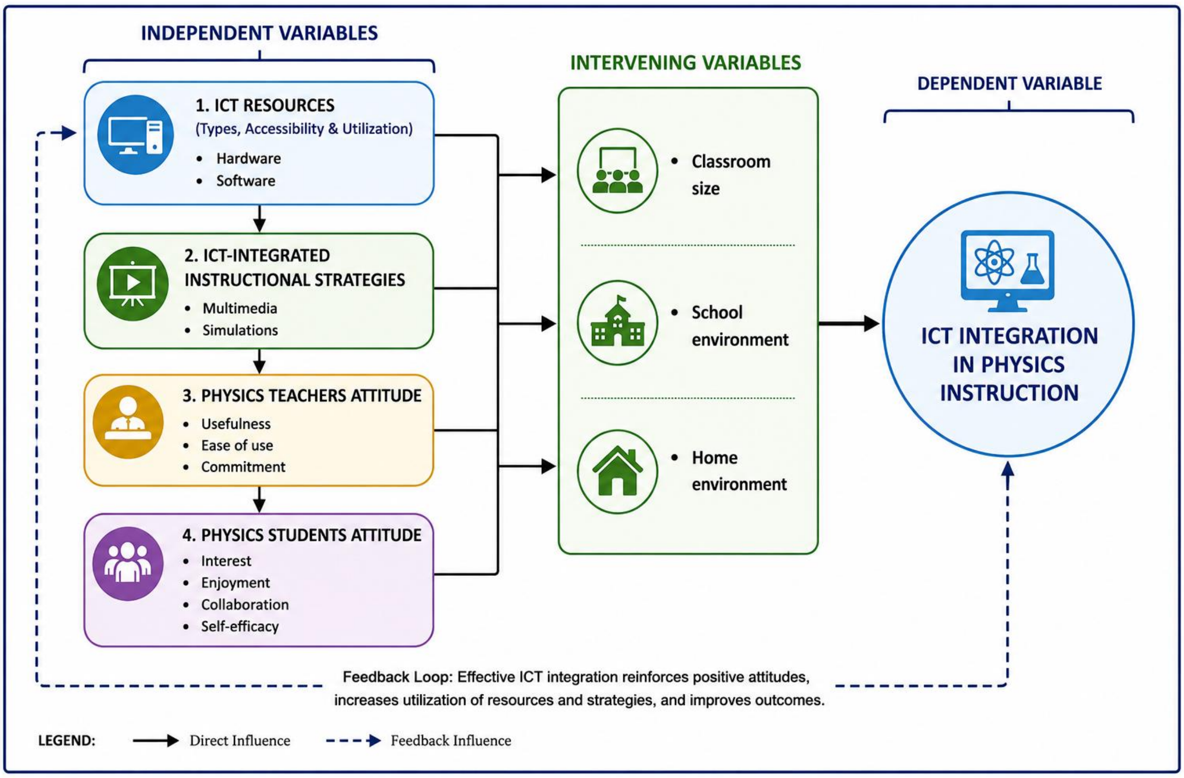
Figure 1 shows the graphical depiction of the TPACK framework that indicates the association of technological, pedagogical and content knowledge with each other as depicted by Fabian et al., (2024) during a systematic review and metanalysis of the framework. The TPACK model has expanded to become one of the most hegemonic theoretical frameworks of educational technology and professional development among 21st-century educators. The ability to understand the topic being taught and instructions, as well as technologies available in the learning situation, is one of the factors that may establish successful technology inclusion in the instruction process. The study examines aspects like teacher abilities, infrastructural setups, teacher and student attitudes, grade level, class demographics, and environmental features that might have their inconspicuous effect on most practices of technology integration in physics instruction.

2.1.5 Conceptual Framework

Figure 2 demonstrates the conceptual framework of ICT-related solutions and inputs for physics instruction at the secondary level. Assuming that the intervening and extraneous variables remain constant, the independent variables (IV) have a direct influence on the dependent variable (DV) which is ICT integration in physics instruction. The presence of ICT tools and strategies in teaching physics is directly related to student performance in the subject as depicted in Figure 2.

Figure 2

A conceptual framework showing various ICT-related strategies and resources, and how they influence ICT integration in physics instruction



From Figure 2, it was depicted that the effective integration of technological tools and strategies in the physics classrooms is greatly influenced by independent variables such as instructional methods, instructional resources, teachers' attitudes and learners' attitudes. These factors reflect both institutional capacity and human factors. The intervening variables, such as lesson time allocation, classroom size, school environment, and home environment mediate the association between the independent and dependent variables, affecting outcomes even if attitudes and practices are favourable. The most significant objective of the study that will be linked to the special tools and strategies employed in the classroom instruction is the dependent variable. The attitude of the teacher and the learner towards the integration of ICT, adequate time, and a favourable school/home atmosphere encourages the integration. The enabling/limiting tools will consist of instructional material/resource, and the classroom size and duration of the lesson may have an influence on the potential of utilizing ICT.

Recent studies by Omariba (2024) support this conceptual framework with the view that positive teacher attitudes with access to functional ICT resources enhance ICT incorporation in the instruction process. The conceptual framework shows a causal pathway in which institutional, pedagogical, and personal factors shape ICT usage in classrooms, but their actual impact is often mediated by the readiness and condition of ICT devices. Effective ICT integration in Physics instruction occurs only when both the environment and the tools align in one direction.

2.2 Integration of Technology (ICT) in Physics Instruction

2.2.1 Definition of Information and Communication Technology (ICT)

The notion of ICT includes all communication technologies, comprising hardware, software, networks, and multimedia resources for teleconferencing, facilitating users in storing, accessing, retrieving, and transmitting information (Heek, 2017). In this study, the word ICT will connote all multimedia elements that facilitate physics education.

2.2.2 The historical approaches to physics education.

In Kenya, Physics is a standard science subject taught and examinable in Form Four of the Kenyan education system, which is being phased out in Kenya. Akala (2021) describes that it is being substituted by the 2-6-3-3 Competency-Based Curriculum (CBC), two years of pre-primary schooling, six years of Primary school, three years of Junior secondary school, and three years of University education. The CBC is focused on mastering competencies and practical skills of the learners.

According to the Kenya Literature Bureau (2009), physics is the subject matter in relation to energy, and also the conceptual framework of the interdependence between matter and energy underlies the study. Physics cannot exist without the knowledge of mathematics to facilitate the learners to operate and explain the physical scales like temperature, pressure, and time. Physics in secondary school is taught in various topics, such as mechanics, optics, electricity, magnetism, condensed matter physics and atomic physics. It also involves the learners in the formulation of hypotheses and testing of the hypotheses empirically in order to achieve the scientific discovery. The applications of the topic in medicine, engineering, transportation, and communication are only a few among the far-reaching applications (Park, 2004).

In general, the justification of teaching physics at the secondary level is to equip learners with the facts and analytical skills in the sciences to become innovative and develop industrial activities. The elementary knowledge of physics, which they would have learned in high school, is expected to be applied by the student learners to the high levels of study, and in the long run, it will assist them in their respective fields of practice. A lot will be hinged on the capacity of the teacher and teaching methods, and then on the presence of the pertinent learning tools to study physics. Although this is important, physics has not been taught and learned in the secondary schools in Kenya as it should have been. The attitude of many students towards the subject is negative, and this is one of the reasons why poor performance is always experienced. Physics is a mandatory course in Form One and Two as well, but it is a choice course in Form Three, depending on the interests and career expectations of the students. It is even more remarkable that the proportion of students who enrolled in physics as science has been significantly lower compared to chemistry and biology at the course of Form Four level, and this is primarily because of the deficiency of qualified physics teachers, the attitude of the learners, and the educational process (Ochieng and Nyang’au, 2020).

The number of students who select physics at Form Three, is around half the total number of students in Form Two due to the seeming complexity of the subject and peer pressure from parents and teachers. Myth has also played a role in developing a gender difference, as good mathematical skills are the key to success in physics, where it is evident that the number of female learners enrolling in the subjects is lower (Wandi, 2023). Absence of mathematical assurance among learners would be demotivating to the learners who need mathematical derivations of principles and laws to comprehend physics. The enrollment and achievement change necessitates the transition to the learner-based models of instruction that also imply the application of technology in learning the concepts of the complicated phenomena. In order to achieve such a transformation, the power of ICT-competent physics teachers needs to be increased. Laboratory experiments and computer simulations are the most significant resources in the creation of the conceptual and practical knowledge of physics in students.

Among the questions that Muianga et al. (2018) asked, the learners were found to be receiving new knowledge more efficiently when they engaged more than one sense and when they were engaged in the working experiment. In Kenya, however, it is the case that most learning institutions do not have well-furnished laboratories for physics instruction. It also lacks qualified teachers and laboratory technicians in situations where the laboratories are available. This means that the available teachers are overworked, bearing in mind that the Teachers Service Commission normally asks teachers to teach different subjects. This is among the workloads that limit the time to be spent on experimentation and giving personal feedback to the students. The argument offered by Wambua (2018) is that the lack of paying a lot of attention to experimental work in physics has affected the internalization of abstract concepts in students, leading to a lack of motivation and interest in studying it. Teachers involved in teaching physics encounter several problems, such as a deficiency of instructional materials, administrative facilities and remuneration provided by TSC.

2.2.3 Technology in the Instruction of Physics

The inclusion of technology in physics pedagogy in secondary school would assist the learners to acquire knowledge of abstract ideas in the physics design. The implementation of a technology curriculum in the physics curriculum entails making of ICT-integrated lesson plans and the appropriate selection of the digital content that would assist the physics teacher to meet the learning objectives as laid out in the physics curriculum (Ramaila, 2024; Bao & Koenig, 2019). In his opinion, Aina (2013) opined that a teacher of physics in the 21st century should be gifted in ICT skills, considering that he/she could choose web-based learning resources and multimedia tools that would now help him/her extend the retention of the content.

The combination of technology in physics pedagogy is highly impactful on the teaching approach of the physics curriculum since it inculcates certain knowledge using the application of pertinent multimedia tools. The radical change in the paradigm shift of the learner to the teacher-centred learning paradigm allows active learning because the teacher is also a co-learner in the learning process. The article by Wambua (2018) reveals that the learner-centred approach has turned into an increasingly popular tendency in modern culture due to multiple beneficial outcomes, such as increased memorization of physics facts and development of critical thinking skills, and arousal of creativity and innovativeness.

According to Stoica (2015), the capacity, knowledge, technologies and preparation are called "*techno*," and the scientific attitude to the psychological state of the mind is called "*logos*." Technology, on its part, is the process of cognition of mental state. To achieve the aim of her article, Aina (2013) and Getahun, et al., (2026) described the factors to why ICT integration in learning is relevant in the 21st century. Physical concepts like the mechanical concepts of optics, magnetism, and electricity are explicated by computer simulations and animation and are therefore easily understood by the learners. The learners of physics will be in a position to operate the computers and laptops, as well as adjust with the physical variables.

The use of ICT gadgets by physics students improves the level of confidence and intellectual capacities in cognitive, psychomotor, and affective levels. Simulation-based instructional programs have been created by software engineers like Encarta and PHET, which allow students to learn more about the concepts of abstract physics, like how an electric motor or an X-ray tube operates. Kenya Literature Bureau (2019) in their Physics Book 3 give an example that describes physics concepts by using computer software, for instance, spinning coils in a magnetic field which makes learning of the concept easier for learners.

Even the discussion concerning how electrical motors and generators operate could present challenges even to teachers in their first year of teaching physics; hence, the usage of appropriate multimedia tools will help the students to understand. The combination of communication technologies in physics instruction will enable the students to learn the information visually, auditorily, and kinaesthetically. The mathematical abilities of average students could also be reinforced by the physics simulations, as they demonstrate that a mathematical problem of calculating the gravitational force with a simple pendulum can be solved (Kenya Literature Bureau, 2020) in the textbook Secondary Physics: Student Book 3.

Multimedia is the digital media that involves the application of different digital media, such as text, graphics, and video, that have been integrated in learning to make learning about the construction of content as conceptualized by Mayer (2009). In Kenya, the number of secondary schools are very few, and multimedia facilities available in the schools could be used by the physics teachers to supplement learning. The multimedia tools, including both motion and still images and films, also help enhance systematic knowledge of the scientific subjects within the domain of physics as opposed to the conventional forms of learning, whereby learning is rooted in lecturing. According to Heeks (2017), the use of multimedia in learning physics to boost the retention levels of students is recommended regarding the learning taxonomy as emphasized by Bloom.

Furthermore, Heeks (2017) asserts that the students can utilize the multimedia materials, including the video, to make the courses more entertaining and interesting compared to the traditional lecture, which is quite dull and boring. Multimedia will be used to improve the attention span of the learners, and, consequently, the knowledge will easily be retained (Okedeyi et al., 2015). The perception towards the students of physics with multimedia is favourable; thus, the government should consider using it as an initiative to advance the enrolment of physics classes in the country. The survey carried out by Okedeyi et al. (2015) indicated that out of the surveyed students, 99 percent expressed interest in studying physics when the multimedia aspects were taught during lessons. The ICT application will therefore be applicable in motivating the learners to concentrate on the courses provided by their instructors.

The articles by Getahun et al. (2026) and Briones (2018) discussing the topic of teachers' competency in the learning and using communication technologies for teaching physics in junior high school illuminates the concept that the rationale of incorporating technology in the instruction process is to offer an appropriate methodology of explicating the complex and abstract concepts in teaching physics and make the process of delivering the lesson more enjoyable. The introduction of ICT as a component in teaching physics has brought new aspects of education that include online learning, virtual learning, and distant learning, which have forced e-education on the traditional teaching processes. Through social media, the amalgamation of technological tools in the education system has formed a new digital world that can be utilized by both teachers and learners to supplement learning (Getahun et al., 2026). The physical faculty can interact with the students at ease via Facebook, Twitter, WhatsApp and other learning management applications that can potentially provide learning materials.

The physics teachers will be able to spread the knowledge via emails and student portals, as hypothesized by Waema (2005), with the internet connection in the schools. The COVID-19 virus has given educational institutions the chance to use ICT technologies, such as computer-assisted instruction, Skype, Zoom, and video conferencing, to provide lessons. The lecture approach does not acknowledge the individual disparities of the students that are requisite in the accomplishment of 21st-century capabilities. Physics would involve the manipulation of numerical problems using computational means and the reduction of the abstract concept. According to research conducted by Hegedus et al. (2017), students have had a few hindrances that hinder their performance level in physics because of poor pedagogy methods, lack of learning materials, and untrained physics instructional staff. The fact that the performance in the national tests is lower in comparison to that of the simpler ones explains why physics is not an interesting subject to the students at the secondary level, as the study by Ugwuanyi et al. (2020) demonstrates.

ICT enables teachers to fulfil the learning goals and objectives with minimum pressure compared to the traditional teaching method, which was the use of chalk and board (Kushwaha and Singhal, 2017). ICT equipment enhances advanced cognitive abilities of analysing and evaluating complex scientific process and good communication through the incorporation of technological devices in education. It is practical since one of the great goals of the technology integration in learning is to make learning closer and more realistic to the real life of the learners. Physics education can make employment of technology to analyse, visualization, for analysis, and experiment, so as to get a better understanding of physics subjects.

2.2.4 The Physics Education in the Modern Vision

As UNESCO (2023) defines it, education may be described as the transfer of skills and knowledge between generations, where one generation passes norms, values, and traditions to another generation, keeping a certain society relevant. It is a determined effort to impart the knowledge and values of a particular generation to another one so that continuity and growth within the society would be united. Education, in this paper, has been defined to be a pool of skills and competencies to boost the productive side of learners (Gastager, 2022). This assumption is also congruent with Waema (2005), who has been familiar with education as the recreation of experiences of learning in a manner that brings meaning to the learning of a learner, which in turn leads to a behavioural response to the evolving environment. Education is hence a two-sided process that not only prepares one to lead a life by reforming their behaviour and providing them with the tools to navigate their world, which is in flux.

In previous decades, educational technology has been an enormous revolution in the education sector that has redefined the way in which subjects such as physics are taught and studied. There has been an overwhelming influx in the amount of knowledge on various sectors through educational technology, and it has offered solutions to various problems, including illiteracy and educational accessibility. The subject of physics, which was once referred to as the philosophy of nature, has undergone a transformation in its approach to teaching the subject in the last two hundred years. Although education about physics at first was all about memorization and education provided through lectures, it has been modified to be more participatory and practical, in which students are introduced to the scientific process and research led by students (Zacharia, 2015) and (Chasokela, 2025).

The study of physics has been seen as a highly significant topic because of the practical use of this science in everyday life. During the 1800s, physics was mostly taught by lectures with the teacher reading a set of notes and extensive use of chalk and board. Fontyn, Fondeur, and Aesaert, (2025) noted that the teachers were regarded as the best knowledge transmitters, and students did not contribute much to learning. The physics course in the secondary level was based on textbook learning, and the teacher was the guru for all issues about the subject. Nonetheless, this kind of teaching was also limiting because there was often minimal content in the coursebooks to be used in instruction and the proportion of learners able to buy physics books was extremely low (Ministry of Education, 2018).

It was a conventional way of teaching physics in Kenya, and the number of students who learned this subject were limited. MoE (2017) also indicated that physics is unpopular among the students in secondary schools. This was alarming to the face of Kenya because the long-term policy was to have Kenya industrialized by the year 2030. Physics is a very significant subject in enhancing logical thinking, analytical and innovation, which are necessary in the development of the industry and technology. Kenya cannot compete in the global market, which needs people with STEM skills, unless the number of people studying physics has grown significantly (Ndemo and Weiss, 2017).

The physics teachers have been at the forefront of resolving these problems, and the solution to these problems has been a learner-oriented approach where more emphasis is laid on the performance of physics laboratory experiments. The transition to a learner-centered pedagogy is a by-product of the broader conceptualization of the pedagogical theory because students will be invited to take part in their educational process as much as they can. An inductive style of learning that encourages students to make inferences about experiments, observations, etc., has been actively employed in physics classes and supports the quality of pedagogy (MoE, 2017). This process is in line with the constructivist methods of learning that assume that the learner constructs his/her own meaning through engagement with the environment and by practicing pragmatically (Vygotsky, 1978).

The slower pace is, however, seen in the implementation of the educational technologies into the physics curriculum, even though the increased significance of student-centred learning that is easier to achieve takes place. This is despite the Kenyan government spending a lot of money in an effort to enhance equity and access. Despite the efforts by the authority to invest in the IT infrastructure in the learning institutions, there has not been an even distribution of technology resources to the educators. The adoption of various technologies in physics instruction, specifically, is a slow one due to the unavailability of training and support and the absence of faith in the potential of ICT to improve student achievement (Heekes, 2017).

2.2.5 Education in Physics in the Developed World-Centred

The pace of technological introduction in education has increased in industrialized countries like America and the United Kingdom. An example of one of these is in the United States of America, where education technologies such as the radio, television, and programmed instruction were invented in the 1960s and a tremendous change in the way education was being provided was introduced. Waema (2005) notes that the invention of new communication technologies in the 1970s, such as videocassettes, remote access audio conferencing facilities, and programmed instruction technologies that enabled more interactive provision of education, came in.

In the 1980s, videotex, electronic mail, and artificial intelligence were introduced and placed in addition to the other tools at the disposal of the educator, and personalized and customized the learning process. Neo et al. (2001) also noted that the end of the 20th century has made the usage of communication technologies in schooling appealing. Also, during the 1980s in the UK and USA, microcomputers were introduced in schools, although the focus was as a learning tool to complement the existing curriculum. To begin with, computers were mostly applied in administration, but the application as a learning tool began to be experienced. Computers, as indicated by the National ICT Policy (2019), later became the source of information storage and retrieval that eventually grew into Information Technology (IT) as a career. By the year 1992, communication had changed through electronic mail usage, and Information Technology (IT) was coined to refer to computing and communication technologies (Heeks, 2017).

The change in the application of technology in education was observed in the 1990s with the innovation of the World Wide Web (WWW). The WWW opened the world where information may be spread, and jobs may be offered regardless of geographical borders. It transformed the implementation of learning in the background, whereby learners could access learning material everywhere in the world. The WWW was also a massive resource in the United States, with an aim of encouraging independent study, under which students were able to access online resources and virtual classrooms and interact with students in other locations (OECD, 2001). The technology application in education was also advanced due to the government schemes that were intended to equip the students to operate in the ever-evolving world. By the beginning of the 21st century, ICT was introduced as the national curriculum in the USA, the UK, Canada, and other developed nations with a focus on teaching critical thinking, creativity, and problem-solving (Ndemo and Weiss, 2017). These were the skills that were considered to be ready for the requirements of the 21st century, when it is possible to be successful in studies and work by having the keys to analysing information, effective communication, and organizing the efforts of people.

The learner-centred model of education was adopted in Singapore; an example is that in late 1998, the government decreased the content in the curriculum by 10 percent and 30 percent, thus making space to implement inquiry-based learning and learning through technology (Gastager, 2022). The effectiveness of these reforms in the established world has become a model for other countries, especially in the African continent, where school systems continue to grapple with the world. It has taken longer and is riddled with numerous issues, as opposed to the developed nations, where the ICT adoption in education has been gradual in Kenya. It has faced one of the greatest challenges in the form of a lack of qualified teachers who have the required skills in ICT. Although the Kenyan government took a giant leap towards the supply of ICT infrastructure in schools, it has lacked skilled human resource personnel that can effortlessly transform these tools to integrate into the physics curriculum (Heeks, 2017). According to Mwadulo et al. (2020), the government has been investing in technology, but the teachers have not been trained, which has adversely affected the learning outcomes.

The other problem was that the attitudinal aspect of some instructors towards communication technologies use in the classroom was pessimistic. According to Goldhaber, et al. (2021), it was noted that some of the experienced teachers in the field of physics are not willing to embrace new technologies since they think that they know how to teach such subjects in the form of lectures and chalk and board. Such educators are likely to doubt the importance of enhancing learning among students, especially when they have already achieved success in the application of more traditional methods of instruction. Additionally, other educators believe that technology is for a younger generation that is more familiar with digital applications compared to older educators (Ndemo & Weiss, 2017). However, the Kenyan government has done the most in ensuring that the digital gap in education is reduced despite the challenges. The use of the National Policy (2019) on ICT was one of the processes of integrating communication technologies in the instruction sector. Five secondary schools in each constituency were established in the Ministry of Education to pilot the technology integration program. Such schools were introduced to computers, laptops, projectors, and internet access, and it was proposed to improve the study of physics and other subjects (MoE, 2017).

Under such a venture, the government, through the organization for Centre of Mathematics, Science and Technology in East Africa (CEMASTEA), came up with champions of ICT who would be at the forefront to embrace the inclusion of communication technologies in the process of instruction. The task of such heroes was to retool tutors in learning institutions nationwide on the incorporation of technology in the lessons they teach and to use the digital resources effectively. This was meant to be the generation of a pool of teachers who could serve as leaders to other teachers and become the driving force of the process of changing the way physics and other courses were being taught (Ndemo & Weiss, 2017). When teachers of physics present PowerPoint presentations by using projectors and computer simulations in the classrooms, they will be able to demonstrate the abstract concepts in interesting and interactive ways. Simulation instruments, such as GeoGebra or PHET simulations, have simplified the visualization of complex physics experiments, and students are expected to feel the concepts of energy transfer and electromagnetic fields better (Briones, 2018). It is through such technologies that the teachers have been able to eliminate the concept of rote memorization and concentrate on inculcating critical thinking and the ability to problem-solve among the students.

Nevertheless, other problems have been associated with the usage of communication technologies to teach physics. Jácome-Mármol et al. (2025) noted that the drawback of the ICT programs has been the expensive nature of both the purchase of the right technology and the lack of resources in most of the rural schools. Moreover, updating and upkeep of their ICT infrastructure has also been another problem in other schools, which hindered the effective implementation of these measures.

Therefore, although the introduction of virtual technologies has led to increased quality of teaching physics in some schools, the general trend has been skewed, with great disparities among towns and cities. The modern view of physics teaching is that of a constantly evolving one. The introduction of ICT in the curriculum has transformed the character of teaching physics to less teacher-centered and more interaction-based teaching methods, as suggested by Makanda (2015). One of the trends that has played out in the developed world is that governments have been investing a lot in the infrastructure of ICT and teacher training so that students can be ready with 21st-century skills. In Kenya, ICT in physics education has been discouraged by poor teacher training, resources, and infrastructure.

2.3 Availability of ICT Resources for Physics Instruction

2.3.1 Introduction

The convenience and ease of operation of the technology devices in the school are one of the most vital aspects in the adoption of technology to teach physics. After the amplified dependence on communication technologies in the field of education, it has progressed to a social necessity that has been considered a predominant practice in economic development. The concept of ICT is defined by Alzahrani (2017) as any communication device (television, radio and mobile phones). The process of globalization of education and the changes in the traditional form of teaching have ensured that the development of communication technologies in the learning institutions assumes very significant scores.

As Karanji (2018) states, the application of ICT in an educational environment cannot be understated; it is one of the areas that are picking up pace in the world, and Kenya is no exception. The Ministry of Education, Science and Technology (MoEST) has invested so much in the application of ICT-related tools in enhancing the quality of education in Kenya. These investments address SDG 4, which strives to "*promote inclusive and equitable education about quality and lifelong learning opportunities for all*" (KICD, 2013). Nonetheless, ICT resources are unequally distributed and accessed in developing nations. In developed nations, serious investments have been instituted so that schools are in a position to have resources that can enable them to integrate ICT. The implication of adequate ICT tools, as presented by Udoh (2010), means that whether instruction of physics in the high schools is efficient relies heavily on the availability of the tools. This part entailed a discussion of the accessibility of ICT resources on both the universal scale and in the country of Kenya, where physics would have to be taught and learned using the tools.

2.3.2 The Conventional ICT Tools of Teaching and Learning

The first technologies that were applied in the education system in history were the traditional ICT tools that included radio, television, typewriters, printers, and the first-generation computers. The usage of radio in instilling the acquisition of knowledge in Kenya was encouraged by the KICD. The KICD (2013) was contracted to traverse across lessons on broadcasting, especially for the primary school learners, on issues that would be addressed at a particular time of the day in school. This was meant to fight the problems of a scarce number of teachers; besides, the students in the distant regions could equally access quality education through alternative means.

One of the cheapest gadgets to broadcast educational information is the radio, as noted by Belay (2020). It can be used in the process of knowledge sharing since it is an invaluable asset when it comes to reaching the students in distant locations where the internet connection or the physical classroom facilities would not be accessible. Other countries, other than Kenya, have also been able to adopt radio-based educational programs. Weru (2018) revealed that there are some countries, like Thailand, which used radio broadcasts to teach mathematics, and Mali, which used radio to teach literacy skills. The radio programs also empowered the rural communities and Sri Lanka to educate about family planning and health-related issues throughout India.

Nevertheless, this wide coverage is not complete, even though the radio covers everything. In a statistical educational report released by the UNESCO Institute of Statistics (2021), about 706 million students live without the use of internet exist around the globe, and about 56 million individuals live in regions where mobile connections are not well-developed. Under the framework of these restrictions, it should be mentioned that the role of the radio and television as a means of education is also acute, even in the regions where the distribution of online education is not widespread. These technologies would allow a viable solution to be identified for the learners who would otherwise be out of formal education.

It was found out that radio and TV were still major platforms through which most African countries could still offer distance-based education programs, as research by Daher (2018) reveals. The developed countries in Europe and North America, on the other hand, have been trending towards more internet-based solutions, though television will have its role. BBC programming, educational in nature, which had started in the 1920s, was also one of the first to make use of mass media in the distribution of knowledge over a wide geographic region. School programs in Kenya started being broadcast in the year 1963 by the Voice of Kenya (VOK). This program was subsequently refined at the Kenya Broadcasting Corporation (KBC) in 2007 to enhance the quality of signals and also make it more cost-effective (KICD, 2007).

To help in making radio programs effective, selectivity is facilitated where learning plans, teacher scripts, and guide plans are prepared to facilitate the learning process. According to KICD (2013), radio shows are capable of boosting the cognitive ability of students, especially the listening and comprehension ability. The effectiveness of these shows, however, depends on how well the broadcasters and the educational authorities are able to collaborate and come up with good qualitative content.

The radio and television as ICT tools in education gained even greater significance during the COVID-19 virus that took place in the world. World Health Organization (2020) noted that with the closure of learning institutions all over the world, most countries resorted to these media as a means to proceed with the education process during the lockdown that followed the COVID-19 endemic. To provide an example, one of the UNICEF projects in Zimbabwe, which was distributing more than 2,500 radios to populations in need as one of the cases where the governments used the traditional ICT tools to guarantee continuity of learning during the pandemic (Doguwa et al., 2021).

There is no indication of the fact that television is actually involved in the teaching of physics. The lack of television as an educational tool was a breakthrough in ICT in learning. In Kenya, education was part of the regular television programming in which schools synchronized their program with the airing. The television also targets the two senses, eyes and ears, as compared to the radio, which only uses the aspect of listening. The visual television is useful in a subject that is usually sophisticated and abstract, as compared to physics. Students who can conclude on variables such as force and motion under controlled conditions can see real-time physical experiments. The physics teachers who will implement programs on television shall make sure that the content of the programs is relevant, captivating, and also at the level of the learner. Zakaria and Khalid (2016) state that television is a desirable method of learning since the theory of sensory stimulation justifies it. This theory enables the learners to trust more than a single sense to be in a position to know everything. In order to facilitate the comprehension of abstract ideas, the application of visual aids and simulations on TV could exhibit a vital role in science education within the context of physics to assist the students in STEM subjects.

The free primary and subsidized secondary school education in Kenya gave the government a chance to broaden the frontier of the education programs in the shape of television. KICD initiated the Educational Channel (EDU-Channel) to address this problem in the hope of delivering quality education content to the learners when there was a lack of teachers. The EDU-Channel vision is to provide learners and teachers with the capacity that they need to excel in their subjects, like physics. The EDU-Channel will, however, prove successful through a chain of factors, even though the potential is enormous. According to the Kenya Institute of Curriculum Development (2013), there is a necessity of having improved signal coverage where all learners, irrespective of their whereabouts, will receive the content being broadcast. The schools should also be provided with the hardware required to enable the content to interact with the students, such as televisions or computers. The opportunities of television as an ICT tool for teaching physics are not explored without the infrastructure.

2.3.3 Physics: ICT Opportunities and Challenges

There are several advantages that are attained with ICT technologies like radio and television, and their use in teaching physics is usually capped with numerous restraints. According to Vancova, (2025) it was noted that among the most relevant obstacles, it is possible to single out the technology gap, which is defined as the difference between the population that can access the technology and the one that cannot. This is a very high disparity in Kenya, especially in the rural regions of Kenya, where there is a scarcity of stable electricity connections, internet, and technology gadgets. Udoh (2010) argues that to enjoy the actual ICT integration, the government has to take care of the infrastructure-related problems that bring about the failure of the schools to fully utilize the available tools. The other weakness includes the untrained teachers. In the given case, when ICT tools are accessible, the majority of teachers do not possess the competencies that could allow them to apply them in their classes. This is further worsened by the reality that the application of communication technologies in the instruction sector is a new thing in most of Kenya. In relation to the study done by Belay et al. (2020), it is believed that the ICT tools should be functional in the classroom, but the teacher should possess proper professional growth and training in accordance with the current trends in the technological sphere.

Nevertheless, there is a lot of potential for ICT improvement in teaching physics despite these obstacles. The availability of mobile gadgets, including smartphones and tablets, is a novel channel of delivery of educational resources. The devices are also dropping to comparatively low prices in low-resource environments. According to Karanji (2018), mobile learning is one of the booming spheres that can ensure the narrowing of the gap between learners and teachers and provide a more flexible and personalized experience of learning.

Besides, another strong mechanism for improving the teaching of physics is amalgamated instruction as process of combining face-to-face mode of traditional approaches with the use of digital devices. Blended instruction can assist teachers in incorporating communication gadgets into their classes without fully overhauling the traditional approach to teaching. The physics teachers can use multimedia devices (simulations, videos, and interactive quizzes) to support the usual lectures and experiments. The tools would allow the students to be in a position to visualize abstract concepts of physics as well as learn through doing. According to Karanjii (2018), blended learning is adaptable, and this causes the engagement rate of the students to increase as they have the option to study at their own pace and can remodel content as necessary, which is why it is the best method of studying such a subject as physics, because conceptual knowledge holds the utmost priority in physics.

The introduction of the CBC in Kenya is the other opportunity that can be used to improve the communication technologies in teaching physics (MOE, 2017). Digital literacy is also among the core competencies of the CBC, and thus, it is ensured that the students acquire skills that would make them capable of working in the digital world. The fact that ICT is being incorporated as part of a curriculum is an indicator of the growing consumer beliefs of the rationale of invention of technological tools in the teaching process and a mandatory commodity in the workplace in the coming years. With all the systems of education adopting the CBC, the demand for ICT resources in the schools that will start the opportunities and challenges in both will have an impact on the teachers and the policy makers.

The presence of ICTs to teach physics would largely influence the modernization of education in Kenya and the entire globe. Although the out-dated ICT tools like the radio and television are still relevant, especially in regions where the internet is not easily accessible, there has emerged an opportunity to improve the learning and teaching process with the fast emergence of technology. Some of the ways through which technology can be used to enhance the teaching of physics include mobile devices, integration, and blending of ICT in the new curriculum.

2.3.4 Kenya ICT infrastructure position

The COVID-19 crisis caused a serious effect on the instruction systems in the world as schools and colleges were closed as countries introduced strict lockdowns to stop the spread of the virus (Belay, 2020). Kenya, like the majority of other countries, faced a pandemic and had to make a drastic shift from confrontational education to a virtual and hybrid one. The transformation demonstrated the discrepancy that was present between the availability of Communication Technologies (CT) infrastructures in the industrialised countries and the developing countries. Adaptation of online learning was rather rapid and successful in developed countries when the ICT infrastructure is at a relatively developed stage as well.

The change was, however, a more difficult one in developing countries like Kenya, where people have extremely limited access to technological resources. The inadequacy of these devices, the internet, and digital literacy were significant challenges to continuing with the learning process throughout the pandemic. It is stated that there are geographical disparities in the availability of communication devices in metropolitan and rustic areas of Kenya (Kenya National Bureau of Statistics, 2019). This unfit is an indicator of additional issues concerning economic inequality, infrastructure development, and gender inequality in technological use. Table 2 shows the percentage penetration of ICT infrastructure in Kenya in 2019.

Table 2

The Percentage Penetration of ICT Infrastructure in Kenya (KNBS, 2019)

Region	Indicator	Gender	Statistics (%) in 2019
Urban	Mobile Phone Ownership	Male	47.60
		Female	47.00
	Use of the Internet	Male	25.10
		Female	20.10
	Use of Laptop/Desktop/Tablet	Male	11.70
		Female	9.00
	Searched and Bought Goods Online	Male	5.00
		Female	3.70
Rural	Mobile Phone Ownership	Male	40.70
		Female	40.30
	Use of the Internet	Male	16.10
		Female	11.30
	Use of Laptop/Desktop/Tablet	Male	6.30
		Female	4.40
	Searched and Bought Goods Online	Male	10.60
		Female	8.60

Table 2 portrays that, on all the indicators, the communication technology infrastructure in the urban and rural regions in Kenya is very different, with the urban areas having high penetration rates. There is a 47.30 percent mobile phone penetration in the urban areas and 40.45 percent in the rural areas. The general difference in regard to the ownership of mobile phones is not a dramatic difference; however, the difference in regard to the utilization of the internet and the ownership of laptops and desktops/tablets is larger. A considerable proportion of 25.10% and 20.10% of the male and females respectively, who are using the net are in the urban places, against 16.10% and 11.30% in the rural places, respectively. This gap creates a technological rift between the urban and rural areas in Kenya, and such a gap can be attributed in large part to the dissimilarity in infrastructural facilities and socioeconomic status.

The statistics also demonstrate a gender imbalance in the usage of ICT, where females are more likely to (in both urban and rural regions) record a low percentage rate of technological access, in contrast to males (KNBS, 2019). In an example, 11.70 percent of male urban dwellers are in possession of laptops, desktops, or tablets, in contrast to 9.00 percent of urban females. The gap is even wider in the rural setting, as it stands at 6.30 percent of men and 4.40 percent of women who have such appliances. These gender differences in the acquisition to technological devices are related to the other access problems for gender in Kenya, where cultural, wealth, and education differences are likely to restrict access to the existing resources, including technology, by women (Herath and Hewagamage, 2015). The large proportion of mobile phones is a good sign that the Kenyans are infiltrating ICT, even though the proportion of laptop and desktop ownership remains low.

The KNBS statistics show that more than 40 percent of the total male and female population in the rural community have mobile phones, but the percentage is higher in the urban regions. Internet and communication are critical resources that cannot be acquired in the absence of mobile phones and in most instances, are the main tools that people use to access learning resources as well as to learn with the digital model of learning (Tarus et al., 2015). Though it must be noted that the mobile phone owners are quite numerous and must be seen in the context of the restrictions concerning internet access and the cost of data. Although the possession of a mobile phone provides an opportunity for digital inclusion, the price and quality of access to the internet are usually constrained by the price of the data plan and the provision of internet access.

It is also not always good in rural areas, and in certain areas, it lacks internet connectivity altogether; hence, the students and teachers are not able to perform all the activities of internet learning. In addition, the data is prohibitively expensive to most of the households and low-income earners, especially, and frustrations can be accumulated when online learning, which is not possible in a classroom setting. The implications of the ICT differences between the regions and the genders are serious for implementation of quality education in Kenya, especially in relation to STEM education, which includes physics education. The absence of computers, tablets, and even quality internet exterminates the opportunities of instructors to implement digital content in their lesson plans and students to obtain access to online learning material.

As Amuko (2015) notes, one of the primary reasons that illustrates why a significant majority of Kenyan citizens do not have personal computers is the low use of computers in learning, thus making them less likely to know the importance of the ICT infrastructure in the improvement of the education outcomes. The insufficiency of ICT infrastructure is also a surety of low standards of teaching in subjects such as physics, where visualization support is in place, and simulation and interactive learning environments make far-reaching contributions in enabling a student to gain an understanding of abstract concepts. The physics teachers at urban schools get a chance to obtain digital resources, i.e., interactive whiteboards, online simulations, and online grading tools. since in urban schools, the rates of ICT are higher, whereas in rural ones, they may have to rely on teaching with chalk-and-board and a limited supply of textbooks, which makes providing interesting and effective lessons difficult (Kariuki and Njihia, 2016; Herath and Hewagamage, 2015). The Kenyan government has found the application of communication technologies in the training sector and has therefore tried to increase the reach of the digital infrastructure. The introduction of technology in the school curriculum and the establishment of the Digital Literacy Programme (DLP) were significant advances in the history of technological application in education. These efforts, though, have not been successful in meeting the same threshold of IT infrastructure provision in schools, where urban schools can get more provisions and investment than rural schools, which are lagging.

The Kenyan government should focus on the allocation of resources by making sure that all schools in the country, despite their geographical location, have sufficient ICT devices and internet connections. The liaisons with the business world could serve as the solution to this gap. One example is that telecom providers can also partner with the Ministry of Education to offer subsidized internet to the schools in rural settings so that learners and teachers will use the opportunities available in online learning without being constrained by the cost aspect (Munyua, 2020). Other than the enhanced accessibility of hardware and internet services, the government should invest in training and retooling of the teachers in a bid to have them in a position to integrate the technology tools into the schooling plans. It will result in insufficient use of even the most efficient digital tools in case they are not supported with proper training, and the advantages of ICT in education will not be used to the maximum. The holistic model of the integration of ICT should be implemented as it is to be adopted by Amuko (2015), i.e., the presence of the physical infrastructure should be complemented by the necessity to provide the digital literacy of teachers and students.

The other highly sensitive area that needs improvement in Kenya to ensure Kenya meets its objective of offering fair education opportunities to all students is the gender gap in the use of ICT infrastructure, as demonstrated in Table 2. The female students in rural areas have lower contact to digital resources and internet services, and hence, less access to online learning tools. The implication of this gap is wider socio-cultural constraints that determine access to education and technological advancement of women, such as gender norms that prefer the education of boys over that of girls in certain societies.

In order to emerge as winners in this obstacle, the government and non-governmental organizations (NGOs) should adopt special programs, which would enhance accessibility of girls to ICT gadgets and internet-based learning forums. Such efforts that help to close me can include the supply of subsidized laptops or tablets to female students in the countryside or mentoring programs that enable females to study STEM-based education and the provision of equal access for female pupils to perform as their male counterparts (Cheruiyot and Kurgat, 2018). It is an example scenario of ICT infrastructure in Kenya, hence demonstrating the greater issues of economic inequality, inequalities of the region, and gender discrepancy in accessing technology. The rural areas are not penetrated with mobile phones, laptops, or access to the internet, leaving the urban centers behind, thereby depriving the teachers and students of an opportunity to experience digital learning. All these issues were only aggravated by the pandemic, as it resulted in the transition of schools to online learning without the necessary ICT infrastructure.

The Kenyan government will be forced to invest more in the procurement of ICT infrastructure, especially in the rural regions, as a way of bridging the gap. Partnerships and programs with the business world, telecommunication companies, and other international organizations can be quite significant in ensuring the popularity of access to digital devices and cheap internet services. More to the point, specific gender gaps in ICT access initiatives are needed in order to make sure that not all female students will remain losers in the digital revolution. Kenya can come up with a system of education that fully utilizes the ICT potential to increase the outcome delivered by the students and give them equal opportunities with the right investments in infrastructure, training, and policy changes.

2.3.5 IT pedagogical teaching resources in physics

Proper technologies can be applied to enhance the physics instruction the learning institutions in Kenya. According to the UNESCO assessment report (2021), various ICT technologies had an opportunity to improve physics education, as they could encourage students and improve the quality of schooling, especially in third-world countries like Kenya.

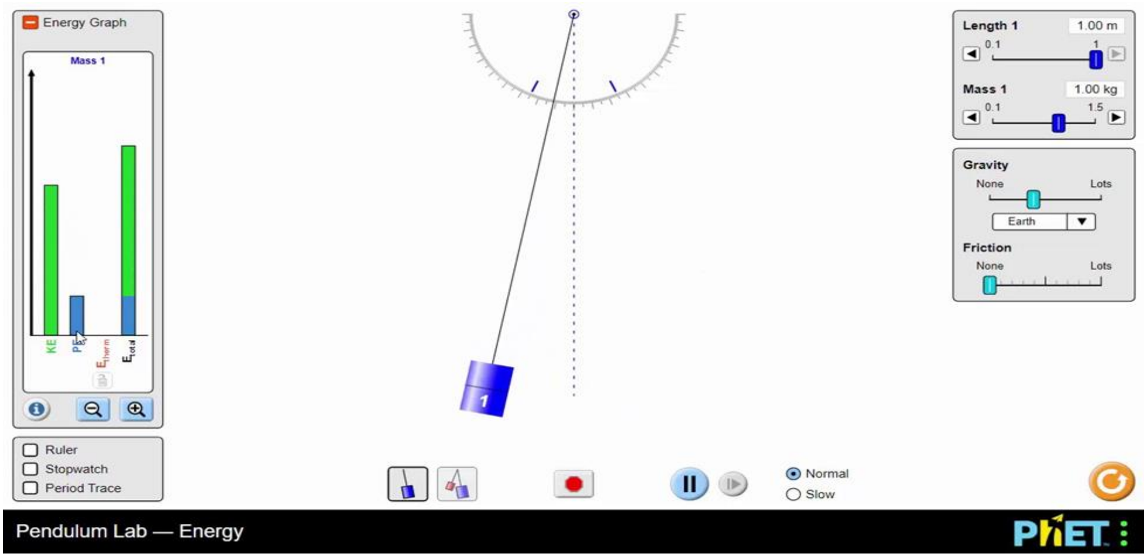
The American Physical Society and MIT Blossoms, which provide mathematics and science video tutorials to high school students, provide physics teachers with teaching aids. On the other hand, NJAAPT offers an educational website, which has a teaching tool in physics as an instrument of attracting more learners to the classroom. The National Foundation of Science offers an online physics classroom that includes a simulation tool. In STEM, there are many custom physics simulations and animations of Science PHET software, which is interactive.

The virtual Physics Classroom is an interactive network, which is based on multimedia and provides courses and simulations, among other instructional resources in physics. It can also be used as a test centre, and students studying physics can be prepared to take examinations. My Physics Lab is an online environment where one can carry out experiments in physics so as to enhance mastery of physics skills and principles. It contains over five hundred simulations that can be used in the study of physics. The physics students will be asked to emphasize the provided simulations and to alter multiple parameters, including the gravity, pressure, weight, length, and temperature. Web-based search engine, Simulation materials, Simulation material search site, Online physics simulation: Edu Media is an online learning simulated laboratory based on the idea of video simulations and quizzing to study physics in the secondary and introductory physics classes of college physics programs. Physics Twitters like @njaapt are also useful sites on which physics tutors can pose questions, answers, and posts about physics-related information, as well as career development courses every two weeks (Abstract n.d.). Twitter physics talk to improve the teaching practices.

The Chinese Ministry of Education developed the General Science Teaching Resources in Grades 7-12, in which published physical resources were developed to aid the students in the conceptualization of abstract concepts. It also targets technological and scientific advancements among students to ensure creativity and innovativeness through rewarding the best physics presentation winner (Ministry of Education, 2017). A basic pendulum was applied to find the force of the centre of gravity when a virtual physics experiment was conducted in Figure 3. The physics learners will be requested to carry out the diagram, specify the variables' length and mass, and graphically illustrate to determine the centre of gravity by altering the original location of the pendulum. The virtual experiment would apply to the rural schools that had limited physics equipment or to the schools that lacked a physics laboratory.

Figure 3

Physics-based simulation of a simple pendulum



Source: *Adopted from PhET interactive simulations*

The students may alter the length and mass of the simple pendulum and count the number of complete oscillations by the press of the button. The number of complete oscillations would help to find the period and consequently, determine the force of gravity. Arnold and Sangrà (2018) noted the availability of numerous free online teaching resources for Physics educators, including Zoom, Kahoot, and THE Journal, which offers materials for schools during the COVID-19 pandemic. Hands-on Physics Activities comprises over 200 simulations featuring demonstrations, mini-labs, and digital experiments that provide clear examples to elucidate physics ideas.

2.3.6 Web 2.0 and 3.0 Content Creation/Sharing Tools

The Web 2.0 and Web 3.0 technologies have significantly influenced the pedagogy, particularly the collaborative learning and participatory learning in the educational system. These internet resources and platforms have altered the normal concept of knowledge sharing and acquisition, enabling the shift of information consumption towards a type of interaction and interactive learning. Whereas the Web 1.0 applications were marvellous and largely suited towards the provision of print or video content form, Web 2.0 introduced dynamic tools that have the possibility of establishing collaboration and interaction, and this made information exchange less one-directional and more community-oriented. Then, according to Arnold and Sangrà (2018), the Web 3.0 technologies remained highly transformative in the learning environments since they integrate artificial intelligence (AI), semantic web, machine learning (ML), and 3D visualization to enhance the creation, delivery, and assimilation of content as further discussed by Miao, (2021). The next section discusses aspects of Web 2.0 and Web 3.0.

2.3.6.1 Web 2.0 Tools: Content Creation and Collaboration Accelerators

The Web 2.0 tools represent a paradigm shift in the creation and sharing of content in the education industry, including STEM education like learning of physics. These tools offer incomparable opportunities for collaborative learning to enable learners and tutors to have interaction in a way that will result in participation and involvement in the education process. The key transformation in the learning environment, which resulted in tools that allowed a learner to both create and control knowledge, was the shift from Web 1.0, which was based on the assumption of passively consuming the information, to Web 2.0, which introduced such tools as blogs, wikis, podcasts, social media, and content-sharing platforms.

Application of Web 2.0 in the learning environment has worked pretty well in instances of emergencies such as the COVID-19 pandemic. As an example, Mavu (2021) has pointed out that teachers in physics on the Web 2.0 platform during the pandemic maintained continuity in the teaching process. COVID-19 led to the introduction of blogs and WhatsApp groups that became a necessity in terms of interaction between students and teachers. In particular, problem-solving and assignments in physics were shared among these platforms, where the students were able to submit their assignments.

This change was the one that enabled learning to continue, despite the fact that face-to-face classes were suspended due to social distancing. Web 2.0 finds application in other fields other than simple communication. Google Classroom, Edmodo, and Slack are the learning platforms that have enabled teachers to facilitate the asynchronous learning process, where students access the content of the lesson and can discuss and submit their assignments as they find appropriate. The tools will encourage collaborative learning, and these features will give the teacher a chance to monitor the students' progress, as well as make immediate comments. According to Livingstone (2015), these collaborative tools are useful in STEM learning since students communicate on a peer-to-peer basis, i.e., in other words, students can cooperate on difficult questions and share their knowledge, thus making it easier to understand through collaborative learning.

In addition to this, Web 2.0 tools provide a platform for self-autonomous learning in which students are free to determine the learning process. As an example, using tools such as Google Docs, students can cooperate in order to work on group tasks in physics, and cooperate at the same time, arguing and editing the same topic under discussion. Such a group project technique is particularly useful in physics, where students often need to share the solution to sets of problems and perform laboratory work, which entails individual input along with a team one.

The Web 2.0 devices have also been enhanced in the level of accessibility and efficiency through the utilization of internet access through mobile media. Learners are now able to participate in the learning process virtually wherever they are, as a larger number of them can access their digital devices like mobile devices and tablets. This is particularly applicable in places where there are infrastructural challenges, and one may not be able to readily access the traditional learning facilities, e.g., textbooks, physical classrooms, and the like. Mobile learning has enabled students to make sure that they can be connected to learning resources and even communicate with classmates regardless of their geographic location to make education more democratic and narrow the digital divide (Miao, 2021).

2.3.6.2 Web 3.0: Making Education Revolutionary with Improved Technologies

Web 2.0 has opened the door to collaborative and interactive learning, and Web 3.0 introduces other advanced tools through which the learning process can be personalized and efficient. The next evolution in the web is Web 3.0, and its purpose is to enhance the user experience of the web and to create a more intelligent, decentralized, and interactive web by implementing artificial intelligence (AI), the semantic web, and machine learning (ML). Omare et al. (2018) maintain that with Web 3.0, decentralized platforms are available, which enable physics instructors to have more sophisticated content development tools and information analysis tools. The tools could help teachers exploit the power of AI and ML and structure the process of learning in a way that would allow giving each student an instruction that would meet his or her individual needs and learning styles. Using Web 3.0 tools as an illustration, the performance of a student, in the case of physics education, can be analyzed, and custom sets of problems provided to the student based on his/her strengths and weaknesses to help in certain learning.

The semantic web aspect of Web 3.0 allows machines to understand the meaning of the concepts in a way that is close to that of humans and exchange content and work together. Miao (2021) states that the semantic skills of Web 3.0 are particularly relevant when studying physics, as complex concepts might be unlearnable. The Web 3.0 platforms can provide contextual explanation and interactive learning patterns through applying intelligent algorithms, and therefore the learning path of the students on the tricky issues can be tracked with much more ease. To give an example, a student with learning problems in Newtonian mechanics can be given extra resources by the system in the form of interactive simulations or video tutorials, depending on the learning style of the student.

2.3.6.3 Learning and creation of content in physics with the assistance of social media

The social networking sites that have become the centre stage in Web 2.0 have been dynamic and have provided handy platforms that can be exploited by teacher educators and learners in producing and distributing learning resources. YouTube, Twitter, Facebook, WhatsApp, and TikTok are highly rated platforms that allow the teacher to create interesting content and provide the students with the possibility to see it when they have at a later moment. They can serve as educational resources and communication tools and in this case, students can find numerous materials, i.e., videos, tutorials, webinars, and podcasts (Hinostroza, 2017).

As Duker et al., (2018) noted, platforms like YouTube and TikTok become crucial in the visual learning process, especially in the field of physics, because students will probably be required to visualize numerous intricate phenomena. These sites were of great importance during the COVID-19 pandemic, when teachers all over the world have posted education videos to ensure that learners are in a position to learn even when they are not in physical classes. The case of the hashtag is responsible for the tendency toward digital learning, since a cumulative number of over 7 billion views on educational videos only in 2020 was reported (Bariu, 2020). It is this unprecedented increase in the making of online content that has led to social media being used as a tool for enabling student-directed and self-paced learning.

Personalized learning can also be achieved by the algorithms that are used on platforms like YouTube, as they suggest the videos that a customer has already had to deal with in the past. This will also help learners to find material that is highly related to the current studies, hence enhancing the knowledge of the learners on more complex issues. However, Hofer et al. (2018)

are also cautious about the fact that these sites are harmful as well, and there are cyberbullying, data privacy violations, and distractions. Therefore, despite immense opportunities for the use of social media platforms as a source of content and learning, teachers must take the initiative to ensure that the students are able to use them responsibly. The Physics teachers can use social media platforms like TikTok and YouTube ethically by selecting accurate, curriculum-aligned content, complying with copyright rules, protecting student privacy, encouraging responsible online behaviour, and using videos as part of hands-on, inquiry-based learning to help students understand physics concepts easily.

2.3.6.4 More Intensive Online Learning Community

Education has been altered with the evolution of online learning environments, remarkably face to face during the COVID-19 crisis. The digital and interactive platforms such as Moodle, Blackboard, and Schoology have emerged as major tools in offering online learning through the provision of the mechanisms that teachers use to create the virtual learning space and manage the whole process of learning. Such tools support the asynchronous learning process, where students can read the materials and complete the tasks at their own time, as well as synchronous learning, such as the real-time discussion and live lectures (Ehlers et al., 2018).

The implementation of "*Massive Open Online Courses*" (MOOCs) as discussed by UNESCO (2023) has been on the increase in Kenya as a way of granting access to education, particularly in the underserved areas. MOOCs allow students to experience individualized learning since students take courses at their own convenient time and place, which involves interacting with other students and teachers through online discussion boards. The Ministry of Education in Kenya has realized that it is important to implement a standardized Learning Management System (LMS) guarantee quality entrance to education, regardless of the location or the socio-economic status.

The analysis of the costs and benefits of the different platforms must be conducted to determine which system would be adopted in the country to be applied on a large scale (Patru and Balaji, 2016). Despite the positive impact that the introduction of the platforms has had on education, challenges have nonetheless been experienced. Online learning has never been fully accomplished since access to the net in some regions is limited, the prices of data are very high, and some areas are digitally illiterate. Therefore, the government ought to emphasize the improvement of infrastructure and the retooling of tutors to ensure that they are not only prepared to use those platforms to the best of their abilities but also sustain their usage.

2.3.6.5 Augmented Reality and Virtual Reality in Physical education

Augmented Reality (AR) and Virtual Reality (VR) have become the most developed techniques of enhancing the quality of education in the world especially in physics, students sometimes encounter abstract concepts that are difficult to master. AR can superimpose digital data on the physical world, where the students can interact with 3D models, as compared to VR, where the students are submerged in simulated settings, and offers a more realistic way of learning. According to Holmes et al. (2019), these technologies enable students to view and interact with scientific concepts, such as atomic structures, electromagnetic fields, and the laws of motion, in a way that is impossible in the case of textbooks or lectures.

AR and VR in physics education may also be applied to turn the knowledge of students in a significant way due to the opportunity to conduct virtual experiments, study virtual objects, and study artificial environments. A case in point is that students will have the ability to pursue the advanced physics tests that they cannot do because of physical equipment (for instance simulating the conduct of a particle in a vacuum). As Gallup (2019) found out, sixty-five percent of the teachers in the U.S. public schools use digital technology, including AR and VR, to enhance the learning process, and 85 percent of teachers who did it reported a greater degree of student engagement and understanding. Of special concern is the fact that AR and VR will be able to provide the individual learning experience, which is particularly appreciable in physics when students are likely to have issues with the visualization of the concepts not easily viewable in the real-world environment. Besides, AR and VR can be offered to special needs students. One such instance is the application of VR in the support of students with autism spectrum disorder (ASD), as it provides students with stress-free learning experiences without becoming overwhelmed by sensory stimuli due to free learning in other classroom settings (Ghavifekr and Rosdy, 2015).

The other technological tool that can transform the education sector is blockchain technology, which can offer transformations in the fields of data storage, credentialing, and academic validation. It is a decentralized registry where it is stored in an immutable and unchangeable format, and this makes blockchain an ideal record storage system relative to student records, academic qualifications, and certificates. Sharples and Domingue (2016) state that one can safely store and share academic credentials through blockchain and present the authenticated academic credentials directly to the employer or university without using a third party.

When applied to physics education, blockchain could simply be used to store the results of exams, assignments, and certificates in a manner that ensures that the progress of students is duly recorded and cannot be altered. It is also decentralized, which offers greater transparency since all the information can be accessed by all the players of the system. Despite the evident potential of blockchain, the questions of scalability, interoperability, and data privacy should be addressed, and once this is done, the blocks of blockchain will find extensive application in education in the future (Sharples and Domingue, 2016).

2.3.6.6 Online Learning Software: Video Conferencing

Video conferencing software is a very modern technology in learning, and its application has been done in a very significant way within the past few years, since schools and institutions of higher learning have embraced distance learning. The applications that have helped teachers to deliver live lectures, present discussions, and have virtual classrooms with students in different locations are Zoom, Microsoft Teams, DingTalk, and Google Meet. Hu et al. (2019) argue that video conferencing tools are a convenient and flexible way of continuing the education process in situations when in-person learning is impossible, such as the case of the COVID-19 pandemic.

Not only have these tools made learning more accessible, but they have also provided methods of allowing the teacher to give customized learning to each student in the form of real-time assistance and feedback. However, the concerns related to internet connectivity and bandwidth limitations are the primary challenges as well, mainly in low-income regions. In Kenya, however, many students lack the reliability of the internet, thereby limiting their opportunities for accessing online learning. The government, therefore, needs to put more resources into the digital infrastructure and ensure that all the students, regardless of their locations, have the means and resources to be successful. Online learning involves the use of video conferencing software in classroom teaching, and "Table 3 offers a description of video conferencing software.

Table 3

A description of Video Conferencing Software for Online Learning

S/NO	Tool	Description	Time limit	Number of participants under the free version	Website link
1	Ding talk	An online platform that supports video conferences, calendar management, and instant message tracking	No Limit	300	https://www.dingtalk.com/
2	zoom	A cloud platform that supports audio-visual	40 minutes	100	https://zoom.us

S/NO	Tool	Description	Time limit	Number of participants under the free version	Website link
		conferencing, chats, and webinars			
3	Teams	Collaborative features integrated with Microsoft Office that involve chatting, meeting, and calling	No limit	250	https://www.microsoft/teams
4	Lark	Collaborative suite with chat, calendar, and cloud storage facility	No Limit	100	https://www.larksuite.com
5	Google meet	Virtual conference system	No Limit	30	https://www.meetgoogle.com"

2.3.7 Studies on the Usage of Communication Technologies in education

Numerous research studies have been formulated to implement ICT in education, but most countries have not fully implemented the utilized the communication technologies in the field of education. The government of Kenya has invested in the usage of technological devices in the sector of education, even though this element is largely applied in schools. In the article by Mwabela et al. (2020) addressing the issue of the "*implementation of ICT and the issues surrounding it in the learning facilities within the Mombasa County of Kenya*", it was established that the integration of ICT in educational setups is low, with the unavailability of ICT facilities and a maintenance culture. The Kenyan high schools also lack ICT facilities, and therefore, the physics teachers are not able to cover the entire physics course due to the inability to use teaching resources. In an inquiry on the usage of technology in learning institutions with Ghana, it was noted that, the absence of sufficient technological facilities was identified as a challenge to the adoption of ICT at school (Kapur, 2014). The inquiry established that 80 percent of the tutors indicated the ICT resources were not adequate as the capacity of the students, hence limiting the successful implementation of the program. According to Ochanda and Indoshi (2011) the introduction of calculators in the Kenyan schools by the Ministry of Education was also an incentive to the learners of mathematics and science to help them with advanced arithmetic calculations.

Similar to the Kenyan schools, in comparison with Nigerian education system, basic ICT facilities in the form of computers, multimedia, projectors, printers, photocopiers, and teleconferencing facilities, among others, are not present in many schools. The unstable and unreliable supply of power in most institutions is also one of the key issues that hinders technology implementation in teaching physics. According to a survey done by Udoh (2010), it was indicated that 81.1 percent of those surveyed did not even use computers in schools since the computers were not available, and 45 percent of the schools only had computers for access by the pupils and not to integrate ICT. The research conducted by the World Bank (2020) indicated that ICT devices that students use in learning, such as email, CD-ROMs, and video conferencing devices, support problem-solving skills since they help students to communicate and make decisions fast. The internet has provided many sources that can be utilized by learners when doing assignments and projects. ICT has to be included into education at various levels of learning, rather than only secondary or tertiary education.

This instils trust between the teachers and learners and follows up with the necessary ICT competences to support instruction for learners as they undergo the curriculum. According to MoE (2022), majority of the Kenyan classrooms do not yet have access to technological devices for instructional purposes. In an educational study carried out by Mwambela et al. (2019), students did not identify email as an ICT tool that is used in the learning process. According to the study, over 40 percent of the sampled carried less than 10 computers, which was insufficient for effective learning, and one in every three schools lacked a power supply to operate the computers. In Kenya, the Teachers Service Commission (TSC) came up with a check-off loan scheme whereby teachers in the government primary schools could acquire laptops to aid in the teaching process, but few teachers acquired the laptops. The teachers had not recognized the relevance of the laptops in the field of education as compared to other sectors of the economy. In the study that was done by Stuart et al. (2009), over 60 percent of the IT devices in learning institutions are serviced and repaired; that is, they are simply left in the storage rooms without being utilized.

There are also schools where old and broken ICT equipment is not repaired or discarded appropriately, since there are no proper procedures or laws that govern the disposal of the old ICT infrastructure. The ICT infrastructure in the school is supposed to enhance the learning process and make it quicker. Bariu (2020) investigated the access to ICT infrastructure in Meru County, Kenya, and discovered that 69.9% of schools lacked computers, which was facilitated by 55.6% of the sampled principals. In order to make sure that the education standards in the country are raised, the government ought to invest in the ICT infrastructure so that all the learning institutions can be equipped.

2.4 ICT Integrated Pedagogies in Physics instruction

2.4.1 Introduction

The teaching of physics in majority of learning institutions in Kenya needs to nurture the skills and values of the learners, to enable them have competencies to resolve of daily problems. Physics teachers must devise proper pedagogy for improving the knowledge and application of physics skills by the students. Wiema and Perkins (2005) state that knowledge transfer between teachers and learners in physics plays a significant part in altering the attitude of the learners and intrinsically encourages the learners to love the subject, unlike the situation at present, where most of the secondary learners abandon the subject after the selection. This is what has been confirmed in the study of Hennessy et al. (2007), which stated that, to successfully impart the 21st-century skills in the students who are studying physics, the teachers should implement ICT teaching methods that will then help them to change the model of instruction from the sole source of knowledge to facilitation of instruction and learning. The next section discusses the ICT-based pedagogies that might be adopted by the 21st-century physics teachers to enhance the effectiveness of studying physics.

2.4.2 Physics Pedagogy using ICT

The pedagogy of physics in most learning institutions in Kenya has largely relied on traditional lectures with very few demonstrations and experiments. The innovation in technology has substantially altered the method in which the majority of the subjects in the curriculum are being taught, hence resulting in the emergence of new skills among the current generation of students. This is the primary purpose of the communication technologies is to simplify the process of instruction delivery and enhance the process of higher-order thinking among the learners.

Jarosievitz (2012) identifies the significance of the application of ICT technologies in instructing physics to enable students to grasp abstract concepts with ease. The teaching of physics puts more emphasis on deriving theories, rules, and principles through the use of demonstrations and experimentation in the laboratory. Physics should be taught using heuristic learning as opposed to expository pedagogy, as is usually the case in contemporary classrooms. The physics knowledge should show that not only the teachers but also the students should know how to use the apparatus well in the lab. Technology in physics offers very diverse virtual resources that the teachers of physics can utilize to help create virtual experiments using ICT resources (Anastasiades and Zaranis, 2017). The learning of Physical knowledge varies with fundamental knowledge and expertise in observation methods and information processing which are essential in converging to the correct conclusion concerning a particular phenomenon.

The report published by the MoE (2021) states that physics applicants were not able to answer the questions about air pressure trapped between columns of mercury, as they were not able to comprehend the concept of the question. The relationships between the air pressure and the pressure of the mercury column and gas could not be depicted by the candidates properly. To have a better grasp of the concept of atmospheric pressure, virtual experiments, in which the learner has been given a choice of changing variables, might be useful. The experiments can be replicated with the aid of ICT instruments to improve the cognitive ability of the students (Abiasen and Reyes, 2021). Moreover, subjects such as the wave theory present the physics instructors and the students with daunting difficulties, as the vibration that results in the creation of waves occurs within a matter of microseconds; therefore, the students cannot observe and demonstrate the process of the formation of waves clearly.

The physics students should be exposed to demonstrations, illustrations, and experimentation of the principles of waves. Chang (2008) reveals that online physics applications can be significantly applied in explaining topics, which in turn helps the students understand. As it was reported by the research works by Valdez et al., (2025) it was found that the students could achieve good grades provided that the pedagogic model applied to teaching physics helped them to effectively learn physics. In Kenya, the Teachers Service Commission (TSC) has trained more than 200,000 teachers on the introduction of technology in teaching methods to improve instruction practice (TSC, 2019). The instructional support strategies will augment the competencies among the tutors of physics to upgrade their practices. The application of technology in the classroom fosters communication and teamwork, and critical thinking among the students.

An investigation by Thohir et al., (2020) regarding how the instructional design based on the web-based methods would influence the competencies of the pre-service tutors revealed that the teachers had the lowest scores in the field of technological expertise. The current teachers in the training colleges are expected to apply the techno expertise gained during training to teach in the classroom, and that is why most of these teachers fail to integrate communication technology into the pedagogy process. When teaching physics, the scientific research must be done in a systematic manner in which the students can gain sufficient knowledge and experience in the subject matter. Abiasen and Reyes (2021) clarified that the topic of physics has been viewed as a difficult and abstract one; nevertheless, this can be simplified by the use of virtual technologies in the presentation of lessons. The investigation carried out by Mwanaszumbah and Magoma (2016) argued that ICT use in physics instruction improves student motivation through abstract meaning clarification, but the process of including technologies into learning is very weak in Kenyan learning institutions. The supplementation of the content presentation is done by ICT tools such as slide presentations that contain interesting content, such as movies, audio, diagrams, and pictures. Virtual physics such as PHET can simulate the physics course of electronics, which is concerned with the flow of electrons.

In his study, Ahmad (2019) explored the roles of ICT in physics learning, relying on a sample of a senior secondary school in Azare, Nigeria, which revealed that Nigeria must abandon the ancient methods of pedagogy for the application of technological devices. The rationale in transforming the traditional form of delivery to the application of technology was to train the 21st-century skills among the Nigerian students. According to Strengthening Mathematics and Science in Secondary School Education (Ahmad, 2019), the issue with poor performance in physics in Kenya is the overreliance on theoretical teaching by most physics' teachers against experiential learning, which improves the interpretation of abstract things.

The study has prescribed the significance of physics teachers possessing ICT competencies that will assist them in their decision-making on the ICT tools to apply in lesson delivery. The relevance of the ICT tool employed by the physics teacher is vital in attaining the objectives of the lesson because it will either render delivery of lessons successful or will be a barrier to the learning process. The introduction of technology in teaching physics is successful under the conditions of the technology skills of a teacher and the presence of ICT studying materials (Makanda, 2021). The report by Makanda indicated that there were numerous physics teachers who were not well informed and competent to use ICT in the high school physics curriculum. The emerging pedagogies, such as collaborative learning, problem-solving, experimental, and social constructivism, are to be introduced that are significant in developing 21st-century skills in students (Kearney and Treagust, 2001).

KICD, has spent time to create the secondary curriculum on an online platform and offer teachers sufficient online teaching materials to enhance their delivery. This is attributed to the fact that secondary teachers can blend the conventional pedagogic practices with an ICT-oriented approach owing to the inaccessibility of ICT-based tools in most of the Kenyan secondary schools. The general criticism that the KICD curriculum is devoid of a clear definition of the circumstances in which the particular ICT tools are to be applied by the teachers to meet the expectations of the learners, as Maithya and Ndebu's (2011) study points out, is essential. Lim (2007) and Polezhaev et al. (2017) explained that the successful initiation of ICT tools can be achieved with the help of the curriculum change that is going to be implemented.

2.4.3 The TPACK Model

The TPACK model is among the impactful theoretical models, which are used to explain how communication technologies are incorporated in the field of education. Agyei and Voogt (2012), Angeli and Valancies (2009), Mishra and Koehler (2006), and Koehler et al. (2008) developed the concept to enhance the contribution of technology in the instruction field. The TPACK paradigm entails technology, pedagogy and content knowledge that are very crucial in good teaching of physics when applied by the teachers appropriately. Technological

Knowledge (TK) plays an important role in helping physics teachers acquire the technology of teaching physics that has been facilitated by the use of the existing hardware, programs, internet, and projectors, among others. The pedagogical knowledge (PK) can be referred to as knowledge of instruction and learning processes, including mathematics and physics materials. Professors of physics are expected to be familiar with teaching methods, evaluation, examinations to identify the achievements of the students, lesson plans, and classroom management.

According to Farrell et al. (2007), the idea of pedagogy is among the key limitations of the Kenyan physics teachers; the majority of them are thoroughly acquainted with the material; however, the lack of motivation to invest and transfer this material to students is a critical factor. It is important that the sequencing of physics material involves the application of the first behaviour of the learner in ensuring that the educator develops a valid lesson plan and the goals that will be achieved at the end of the lesson. Nguyen and Williams (2016) emphasized that the Content (C) element presupposes that the instructors of physics must be knowledgeable enough in the field of their specialization, including the simple concepts, rules, principles, strategies, and theories that become central in the development of the process of successful teaching.

Teachers should be familiar with physics; hence, there is a need to normalize the training program of various teacher training institutions and universities such that the teachers possess similar knowledge and skills of teaching. According to Yeh et al. (2014) "*developing and validating technological pedagogical content knowledge in a practical Delphi survey technique*", the three elements of TPACK are contained, and thus, the model becomes even more applicable. Pedagogical Content Knowledge (PCK) is a kind of intersection between subject matter and pedagogical knowledge (Shulman, 1987).

Pedagogy and content are significant in teaching physics, as they enable the instructor to apply the proper methodologies of teaching a particular body of the physics curriculum, thereby enhancing the degree of cognition of students on a particular topic. Cox et al. (2004) noted that, teachers need to adopt the theory of connectivism in developing relations between the material and pedagogy through the lens of viewing the innate behaviour of learners. Teaching physics requires that a teacher be well-equipped in terms of knowledge so as to understand the structure and designation of the physics curriculum and ICT-based pedagogies and instructions, like demonstrating, experimenting, discussing, and exploring, to impart the contents most effectively. The structure or the pedagogy of the physics teacher plays a major role in possessing an intrinsic motivation to study the subject. Most physics teachers adopt the lecture mode, which does not allow students to concentrate on the material; therefore, they fail to comprehend the real uses of physics material. Physics is the empirical science, which entails demonstrations and illustrations, which entail the use of ICT tools, which may be used to supplement the traditional laboratory tests and assist the learners to appreciate what they are being taught.

Technological Content Knowledge (TCK) is an amalgamation of technology in instruction and understanding of physics material. Notably, the physics teachers can make decisions on the appropriate technology that will enhance the delivery of the knowledge to potential learners. The fact that the studies by Rutten et al. (2012) and Mikropoulos et al. (2018) reveal that there are many emerging technologies available in the market, and the dynamic nature of technologies means that instructors need to be instructed on the usage of these technologies in training physics. Technological Pedagogical Knowledge (TPK) may be described as the ability to use technological pedagogical methods in teaching physics. It also involves the knowledge of the technologies at hand, e.g., the projectors and the presentation against web-based learning tools, so that the process of teaching physics in the classroom can be facilitated. To utilize the TPACK model, the physics teachers should be trained on what technologies they can use to adequately improve pedagogical processes in their classrooms. This is because the definition of the TPACK model in the writing of Mishra and Koehler (2006) is the critical capability required of the 21st-century physics teacher who would wish he/she could empower his/her students with the competencies they require. There is a necessity to incorporate the technology models in training colleges and universities so that the ICT-related tools can be properly implemented in the instruction process.

The knowledge of TPACK paradigm, the physics teachers will be in a position to incorporate communication technologies into their instruction with ease. The presentation of technological devices was 16.8 percent, and the application of ICTs in lectures during the training was extremely low, according to the study by Peeraer and Petegem (2011) carried out in Vietnam. This has been ensured by the Ministry of Training and Education in Vietnam, which has continued to invest in IT infrastructure and training of human personnel to ensure integration of communication technology in training. Discussing the socio-cultural theory within the framework of the theory expounded by Vygotsky (1978), it is the effective interaction with the surrounding world that will be capable of assisting the learners in building knowledge. The environment consists of physical learning tools like ICT tools, physics laboratory tools and teachers, which are important in the dissemination of knowledge. A good teacher in physics has the duty to guide the students and identify the social aspects that affect the learners and give them a favourable environment for learning.

2.4.4 Pedagogic Practices of Physics Instruction

The purpose of physics in the world is to promote technical innovations, to promote the production of wealth, to improve the time of health of individuals, and also to spearhead industrialization in third-world countries. The theoretical and experimental approach establishes the learning of scientific concepts of physics in learning institutions within Kenya.

In the case in question, physics teachers are mainly dependent on the conventional method of lectures, which means working with chalkboards and verbal explanations, and the number of instances of practical demonstrations is not numerous. Amadalo et al. (2012) established that 90 percent of the physics tutors used the lecture approach instead of adopting the approaches facilitated by ICT integration. It was also discovered that a quarter of teachers in physics make use of the lecture method and the experimental method. In the Kenyan secondary schools, the lecture style has made physics go through a boring study that is associated with complex mathematical calculations and thus is very hard to study. Application of the lecture technique has contributed to the reduction in the proportion of learners who would desire to study physics in secondary learning institution and probably the few students who study the subject get poor grades in their studies.

The overwork and unrealistic teaching styles render the teachers unable to diagnose the knowledge gaps and learning deficiencies of the students in physics in order to develop their competencies and values. According to the research conducted by Okedeyi et al. (2015), physics students who have low mathematical ability are unable to use mathematical tables and numbers, diagrams, graphs, and equations, which eventually leads to the students failing to score high marks in the subject. The teacher will have to rely on the skills, the interests, and the learning objectives of the student to make ICT strategies and increase the performance of the physics students. Experience would also come in handy in helping the learners in learning the abstract physics. Physics teachers lack teaching materials, and therefore, the teacher must provide an elaborate guideline on how to experiment; otherwise, the teacher conducts and does the experiment in front of the students during the practical assignment. Educational physics applications would also enable educators to use computer-assisted practical works through ICT usage in the teaching of physics (Jimoyiannis, 2011). The computer-aided task is performed with the help of the data sensors that are connected to the information data logger that is available, and the information is presented on the screen in the form of graphics.

The students of physics can also store the data in an electronic device as opposed to the old-fashioned approach of using paper and a pen, which will most likely record errors (Cousik, 2015). The learners in the virtual experiment concentrate on a virtual experiment as opposed to the real experiment, where the learners concentrate more on recording the results of research than on the real research. The printing of the information related to the real-life trials is usually more prone to cumulative errors as compared to the computer experiments. Baltzis and Koukias (2009) voiced their opinion that virtual experimentation denied the learner their entitlement to physically manipulate variables and, therefore, could not equip the learner with the much-desired psychomotor skills that are crucial in addressing business problems. In Kenya, even the teachers of physics are not yet ready to conduct virtual experiments, instead using the laboratory experiments as traditionally used.

It is important to state that even in virtual experiments, the learners would have been forced to manipulate the variables they would have been investigating with ICT instruments so as to provide realistic and valid observations. According to the paper by Akkoyunlu and Soylu (2008), blended learning is extremely significant to both the teacher and students, especially in cases where resources are scarce. In case an experiment is done by the physics students to determine the rate of reaction by using the gas syringe and sensor, the students have the possibility to follow the experiment and take notes at the same time. The learners in physics will be in a position to come up with graphs, to be in a position to make decisions, and to make inferences regarding the given observations. As Zewdie (2022) says, the computer-aided graphing design can provide a more accurate graphical representation of the experimental data in connection with the traditional graph-drawing processes that are considered prone to error in statistics.

The ICT-incorporated strategy is mainly aimed at increasing the level of success among the learners as compared to the conventional teaching strategies. The learners have complete control of the learning process and can manipulate the experiment factors with the help of ICT resources in a manner that fosters their grasp of the concept under teaching. Learner-centered strategy nurtures the competencies and values of students. Uwizeyimana et al. (2018) recognize the teacher-centred approach as among the biggest impediments to teaching physics in high schools in Rwanda. It was also proposed in the study that the researchers would apply class experiments, problem-solving, project-based learning, collaborative learning, and cooperative learning to facilitate critical thinking among the learners.

The traditional education system is based on a question-answer format, which is favourable to the high-achieving students but unintentionally demotivates the less-achieving students who have difficulties responding to the questions posed by the teacher (Gobena, 2019). The learning process with the inward and outward students will involve the use of ICTs because they will have time for studying the material and rereading and rereading the difficult concepts. The use of ICT tools can be noted to motivate the physics students when they find it easy to connect the content that is being taught in the classroom with their experience. The ICT pedagogies are also designed to maximize the student-centeredness and equalization of the teacher and the learner perspectives in the subject being taught (Fahraeus, 2020). The repetition and practice of the physics exercises will be supplemented with Computer-Aided Instruction (CAI), which will improve the in-depth thinking and analytical approach of solving issues among the learners. The problem of shortages of teachers, lack of resources, and the impossibility of direct observation of the subject matter, along with the teacher-centred learning styles that teach physics in the classroom, have been established by Dawes in his book, "*What Stops Teachers Using New Technology*" (2001), as the determinants that affect the execution of the secondary physics curriculum.

2.5 Attitude and beliefs of Physics Teachers on the use of ICT in Physics Instruction

2.5.1 Introduction

The attitudes and perceptions of the physics teachers are variables that has an impact on the inclusion of communication technologies (CT) in global field of schooling and acquisition of knowledge among the learners. Fishbein and Ajzen (1980) use the term "*attitude*" in their book, Understanding Attitudes and Predicting Social Behaviour, whereby the term "*attitude*" is the positive or negative feeling towards the given behaviour or act and the term "belief" is the subjective approach to the knowledge that is perceived by the individual as true that is established through the content matter or through personal experiences and feelings. Attitude towards psychologists is the beliefs, emotions, and behaviours taken in the form of observation and feeling towards a subject or a person. There are various studies that have been conducted regarding ICT integration, but the majority of them include the availability of ICT resources to the learning institutions; rarely are the perceptions and faith of teachers regarding ICT integration in education considered (Abedi, 2024).

A trend has been noticed in Kenya, where most of the schools have ICT tools that are currently being exploited by the majority of teachers who are not actively involved in the learning activities. Most teachers have no interest or skills to utilize ICT, and hence, it is not an aspect of the learning process that most teachers consider. With the use of behavioural conditioning theories, the classroom behaviours of teachers and students can be explained using classical conditioning, observational conditioning, and operant conditioning necessary in causing cognitive change. This, in turn, implies that when physics teachers use ICT to teach, there must have good persuasion to cause positive attitudes in the learners and prevent undesired conventional pedagogies, hence promoting the application of technology in teaching (Jimoyiannis and Komis, 2001).

When the teachers grasp the importance of technology application in their practices, thus generating learner-based practices, the attitude of the teachers can be changed. According to the study by Mwangi et al., (2020) it was noted that physics education change is radical because it is instituted to align the competencies acquired by the students with the requirements of the 21st century, including analytical and daily problem-solving techniques. The type of perception that teachers assume the task of information technologies in the field of education is relevant in determining their rate of acceptance of the instructional activities. Thus, a positive attitude would enable the teachers to create exciting and creative learning in the classroom. However, issues of self-confidence, refusal to accept to change and negative experiences represent significant obstacles that can deter successful inclusion of communication technology (CT) in physics education. The solution to these gaps is vital in the actualization of an effective process of virtual technology integration because it is a continuous process of professionalism whose key element pertains to mindset, pedagogical expertise, and technical ability. The favourable and healthy climate around technology integration has the potential to instil the culture of innovation and constant improvement in the field of knowledge acquisition, which will result in more effective teaching processes that will eventually help the students to nurture their competencies.

Attitude and belief differences, therefore, were major concerns that ought to be included when teaching physics through the incorporation of ICT. The physics teachers will be forced to rethink their mindset to see physics not merely as imparting knowledge but as creating a potential in physics among the learners that will enable them to contribute to the economic growth of their nation. As the research has been mentioned in the study by Bindu (2017), the conditions of the provision of 21st-century skills to the students presuppose the availability of instructors who possess the ICT competencies and digital literacy skills. The emerging nations like Kenya need students who have knowledge of physics that is vital in the advancement via the industrial revolution and provision of employment prospects to the jobless youths. This section evaluates the impact of the attitude and viewpoint of the educators in physics on the usage of communication technologies in physics pedagogy. Other secondary schools in Kenya could have the ICT facilities, but the teachers hardly use them in an instructional manner. In that regard, the study depicts a fundamental aspect in determining the psychological problems that prevent teachers from using technology in schools by the teachers. The point that majority of the educators think ICT application in education is a new pedagogy that is ideal in the digital age, and that might not influence the generation that is aged, is a misguided point that might not be the case. There is also the need to continuously sensitize and train the instructors on how to apply communication technologies in teaching in order to gain confidence and feel that they need to apply this new method. The ICT training and sensitization will ensure that the physics teachers decide on the appropriate ICT equipment for the appropriate topic, hence enhancing the quality of teaching.

2.5.2 Attitude of the Physics Teachers

In the case of the paper presented by Jimoyiannis and Komis (2007), the word "attitude" was defined as the tendency towards maintaining a steady response to a particular goal, either positively or negatively. The psychological scale of attitude among the teachers measures such aspects as anxiety, self-efficacy, technology avoidance, technology interest, utility of technology, fear of computers, and liking of computers in their daily life (Ogundile et al., 2019). The approaches of the physics tutors to the integration of communication technologies into the classroom are evaluated using independent variables that are determined by age, gender, training skills, and accessibility to ICT tools, as well as the experience of the instructors. Physics teachers are highly critical in their attitude as they decide whether to incorporate telecommunication devices in education or not. The most crucial one is that education stakeholders should critically analyse the variables that may be responsible for the failure of teachers to embrace ICT in the instruction processes. Physics teachers must be friendly to the evolution of technology into their teaching so as to adopt it in their instructional process.

Upon citing the study conducted by Onwuagboke and Singh (2016) on the perception of the college tutors on the inclusion of technological devices tutoring, the inquiry depicted a gender difference between the male and the female tutors, as the male tutors are more positive regarding the usage of technologies in education than their counterparts. The fact that ICT adoption in education is positively viewed does not necessarily mean that the integration has taken place; nevertheless, the ability and willingness to use ICT tools are what determine the outcome. Yehya (2019) determined that the insight of physics teachers towards the incorporation of communication technology to teach physics in Lebanon was colossal in influencing the adoption of virtual technologies to teach physics. The study considers the tutor in physics as the most relevant in the successful incorporation of communication technologies in the field of education.

The attitude of teachers will ascertain whether the ICT implementation will be successful in teaching physics (Angadi, 2014). The specified positive attitude can be related to the level of skill of teachers and the attitude of a teacher to ICT in education (Yehya, 2019). The reluctance of other educators to use technologies in the learning process is also noticeable, as well as the discussion of technological manipulation and incompetence in ICT. Integrating communication technologies in the field of physics instruction would necessitate the instructors being ready to select and implement appropriate technology in teaching the lessons. The procedure for technology integration is founded on the point of attitude and judgment of the teachers and the opinion of the instructors regarding the educational process (Ogalo et al., 2022 & Galanouli et al., 2004).

2.5.3 Aspects influencing the attitude of physics teachers

The ways of the physics tutors to integrate technology in the classroom are predetermined by the psychological factors that hinder or trigger the implementation of the new teaching methods. There are more psychological considerations, which involve being strongly connected with the tutor's attitude towards communication technologies, as well as their certainty in the possibilities of technology to upgrade the condition of instruction. As Gonzalez-Sanmamed et al. (2017) imply, the teacher's beliefs were observed to be critical concerning the formalization of successful application of Communication Technology (CT) in the field education since they are directly related to the perception and the bid of new communication technologies in the classroom. The propositions are also defined as beliefs, which determine the course of teaching, and attitudes, values, preconceptions, and assumptions are the propositions (Fives et al., 2015). Such beliefs play a significant role in informing the way the teachers incorporate the ICT tools in their instruction.

One of the issues that defines the successful implementation of technology is the mental attitude of physical instructors towards classroom inclusion of technology. The attitude of the teachers will show whether they will tend towards the more modern and learner-focused approach of utilizing technology in comparison to the more traditional and teacher-centered one. Education practices in the world have also evolved in the past few decades as most countries in the world reorganize the design of their curriculum to embrace the ICT integration in pedagogy, like Kenya. The changes in the world towards digital literacy have witnessed Competency-Based Curriculum (CBC) being introduced by the government of Kenya (MoE, 2017). The CBC design is also expected to guarantee the capability of the learners to obtain the applicable competencies that can make them perform successfully in the modern world. The curriculum in this respect considers Sustainable Development Goal 4, quality education as a tool for the elimination of poverty and settlement of conflicts (MoE, 2017).

The ICT integration as anticipated in the CBC curriculum cuts across all the learning levels, and learners therefore end up attaining skills in digital literacy after completing their studies. To see the success of such an integration, however, the physical education teachers in the high school have to be eager to forget their old system of thinking and embrace the new technological revolution brought about by the new generation (Buabeng-Andoh, 2012). The issue of resistance to change, especially among seasoned teachers, can have an immense effect on the success of technology in the learning institutions. The teachers will also be required to be psychologically persuaded to take up the new technologies because it will entail altering their perceptions and teaching approaches.

2.5.4 Personal, Technological and Institutional Factors Influencing Teachers' Attitudes

Scholars have determined that the attitude of the physics teacher towards the usage of communication technologies is determined by a number of factors. These causes may be categorized as personal, technological, and institutional (Buabeng-Andoh, 2012). The personal factors involve the age of the teacher, his/her gender, his/her experience in teaching, their emotional state, and their personal thinking. These are powerful motivating/demotivating forces that predispose or disincline teachers to adopt technology in teaching or otherwise. This can be illustrated through the example of young teachers, who will be more open to the application of technology, since they are more acquainted with technology, and their older counterparts will be hesitant to make changes, simply because they were not informed of how to effectively use the technology or the fact that they have little confidence in the fact that they can effectively use the technology.

In one study conducted in the USA, Hong (2016) attempted to establish the attitude of the college tutors regarding the integration of technology was established. According to the findings, a massive percentage of teachers believed that ICT was a viable learning resource when it comes to providing instructions and as an aid for storing and retrieving learning information. The teachers who were part of the study valued the fact that technology provided them with the flexibility in delivering the lesson and were therefore in a better position to utilize communication technologies in the learning process. Nonetheless, the paper also discovered that the teacher's beliefs and psychological readiness were also very critical in the adoption of the ICT tools. The teachers would not be happy whether the new technology is available or not unless the teachers are well prepared (mentally and emotionally). To make sure that the ICT integration is present, it is important to mention that the availability of the technological tools is not enough. It is expected that the teachers should be equipped with skills and knowledge of how to utilize the ICT tools and ensure they arrive at ICT-integrated lesson plans.

The technological devices should also be included in the lesson plans because they will improve the process of learning and make it more interactive and fascinating to students (González-Sanmamed et al., 2017). An example of this is the subject of physics, which would make it easy for learners to understand abstract concepts because simulations or visualizations are being used. Nonetheless, the implementation of such instruments is to be planned, and the teacher ought to demonstrate the desire to change the form of instruction that is traditional to a technology-based mode of instruction.

The other factor that alters the dynamics of the attitude of the classroom learners is the effectiveness with which the teachers employ ICT tools in the lesson. Once the students become conversant with the technology that is being applied, they will be in a position to react to the learning process more favourably. The interactive nature of the students through interactive devices, including animations, simulations, and virtual laboratories, also allows the students to have a flexible and interactive learning experience, hence a positive attitude towards physics and the growth in the required skills (Fraillon et al., 2013).

According to the research that has been carried out in various regions of the world, it is agreeable that despite the many efforts that have been made to ensure that communication technologies are integrated in the education sector fully, there are still significant numbers of schools that are still grappling with the integration of technology. For instance, based on a survey conducted for the "*International Computer and Information Literacy Study*" by Fraillon and co-authors (2013), the integration of communication and information technologies is still low in majority of learning institutions across the world. The research that included part of the Commonwealth countries showed that despite the educational development in such European nations as Poland, Germany, Ireland, or Belgium, the utilization of technological tools in the educational process is not higher than the average of the "*Organisation for Economic Co-operation and Development* (OECD)" (OECD, 2015). This demonstrates that issues of ICT integration are not only specific to third-world nations such as Kenya, but they have cut across the board.

There are also several reasons that are attributed to the little use of ICT in schools. Fullan (2012) confirms that certain internal elements, which include the beliefs of the teachers, classroom experiences, and resistance to the new teaching methods, are the biggest hindrances to ICT integration. A study by Albirini (2006) of the Turkish teachers in Syria, Heirati and Alashti (2015) of the Iranian teachers, Al-Zaidiyeen et al. (2010) of the Jordanian ones, and Bindu (2017) of the Indian ones all evidence that tutors tend to have a positive mindset toward the incorporation of information technologies in the field of training.

Nevertheless, regardless of such optimism, there is not much done in the combination of technology in the education procedures. Attitudes of the tutors are then more important in either adoption or non-adoption of technology in the classroom. The school administrations are expected to assist teachers financially and morally in order to ensure that they adopt a positive stance in the integration of these ICT (Buabeng-Andoh, 2012). The technological tools cannot operate independently, even though they are important in the provision of the same. The teachers are involved in technology integration in the curriculum. Even the best technological resources would not help improve the process of learning unless the teachers are concerned.

Houcine (2011) has noted that the ICT integrated concepts in education goes beyond the supply of the hardware and software. It involves alteration of the teaching philosophy in which the teachers are expected to be student-centered in their teaching. This transformation cannot be made without a positive attitude from the teachers. Integration of ICT is incomplete without a wish to change, since it will never be more than a mere superficial and inefficient endeavour.

Attitudinal differences between genders also contribute to the level of technology adoption in schools, insofar as ICT integration is concerned. In Kenya, female teachers, on the other hand, have also been reported not to embrace communication technologies in the field of education, which has been cited as a major obstacle towards the use of virtual technologies in Kenya (Buabeng-Andoh, 2012). This is a serious gender disparity, as this restricts the opportunities of having equal access to technology among students. Gender equality should also be applied in the adoption of ICT, as teachers of the male and the female genders should not hesitate to use technologies in their instructions.

The attitudes of Kenyans towards ICT in terms of gender are not specific to Kenya only but research carried out in other countries has shown that it is the same, since male tutors are more inclined to take on technology in their instruction procedures than their female counterparts. Such a difference may be attributed to the social pressure or cultural values, or the inability of female teachers in the field of competence to utilize technology (Albiruni, 2006; Bindu, 2017). The problems should be solved by offering special training and assistance to the female teachers so that they are equal in the sense that they are ready to utilize ICT in classes.

Finally, one more aspect that can be regarded as a condition to effective implementation of technology in the field of teaching is the optimism of the tutors in the sphere of physics. Nonetheless, they can have a rather substantial impact on the college tutors by either stimulating or discouraging the incorporation of the information technologies in the classroom because of personal, technological, and institutional aspects. To effectively incorporate the usage of communication technology, the instructors must be equipped with technical skills to operate ICT tools, besides being psychologically and emotionally prepared to adopt new teaching techniques. The Kenyan Ministry of Education should appreciate the fact that technological tools should not be made to developed with the intention of making the ICT integration effective.

The teachers will be professionally developed continuously and will be provided with emotional assistance and access to the resources that would make them feel confident and competent when using the technology. One of the good practices that may lead to effective inclusion of ICT in education is teacher interaction, because the attitude of teachers directly depends on the attitude of their students. In the digitalized world where digital literacy is gaining significant attention, there is a need to foster the positive disposition towards technology that the teachers have, as well as among the learners, to reach the desirable educational results that are dictated by the 21st-century world.

2.5.5 The Pedagogical Beliefs of the Physics Teachers

In Kenya, most of the teachers are knowledge transmitters, and a very minimal percentage of them are knowledge facilitators since they assist students in building their own knowledge. The teachers who are knowledge transmitters (physics teachers) are those who use a teacher-centred approach as opposed to the knowledge facilitators who use a learner-centred approach. The facilitators aid in the utilisation of the knowledge by working with the learners and deliberating on how to solve the problem using the integration of communication technology with the aim of augmenting the active learning approaches. The other study that was carried out on the problem of Pedagogical beliefs of South African physics teachers towards inquiry approaches by Ramnarain (2024) further expounded the findings of the investigation is that the tutors should distinguish the general beliefs from the educational beliefs. The pedagogic belief Educators assert that the application of IT in the instruction process is mandatory to make it effective. Beliefs imply the devotion, ideas, or assumptions that entail personal norms in the pedagogical and learning process (Ramnararain, 2024). The idea of philosophical beliefs, as expounded by Ramnarain, was used in this paper that the teachers of physics should have enough information to make wrong or wrong decisions in embracing technology to teach.

In Kenya, the teachers have been well-trained, though there is still a need to guide them on how to incorporate technology in the classroom. Therefore, competencies acquired during teacher training programs and views about the teachers concerning the application of technology in teaching physics bear a significant relationship. The teachers will be expected to accommodate the new ICT approach as long as they are convinced that the change does not oppose their personal beliefs. It was determined that the study done by Tsai (2002) indicated that instructors of science who subscribe to the empiricist traditional ways of teaching usually impart the students with the facts of science by delivering the knowledge in a simplistic manner. The different training institutions significantly influence empiricist educators; hence, they cannot integrate communication technologies in the procedures of instruction. Further, the tutors can use such technology that has a habit of adopting technology and changing their teaching techniques to fit their own ideologies in order to meet their teaching objectives. The selection of ICT tools to be applied to teach the lesson is dependent on the teacher's attitude.

Physics educators do not believe in a particular problem in a specific way, but they vary based on the external forces that cannot be easily measured with the help of empirical study.

The majority of the research has determined that teachers in the constructivist stance depict positive feelings on the implementation of technology in the instructional process Al-Zaidiyeen et al. (2010) in Jordan, where there were 650 instructors, the determination of the investigation was to establish the level of ICT usage and how it related to attitude to IT in education, and they also came up with the same finding, that is good relationship between the two variables. Their study reached a conclusion that the physics teachers should focus on the incorporation and combination of technological tools in the classroom with the aim of making them achieve effective learning and international standards.

The findings of the research conducted by Bakr (2011) on the Attitudes of Egyptian teachers towards computers are collaborating with the outcomes of Al-Zaidiyeen et al. (2010), who stated that tutors in Egypt have a strong correlation towards the inclusion of technology in the educational procedures. ICT tools are significant in changing the instruction procedures Teachers working in physics have to think about the incorporation of technological devices in their work schedules since children live in the era of the digital world, and they should be prepared to have the skills relevant to the 21st century to be successful in the future (Davis, 2017). As it has been identified in the article by Ngeze (2017) and Kihoza et al. (2016), teachers are frustrated about the usage of virtual technological tools, while some tutors simply struggle to resist the implementation of the new teaching method.

The role players in the facilitation of the IT integrated approach into the pedagogy process are the educators. The college physics tutors might be happy with the usability of the ICT in educational systems, but do not apply technology in the classroom because of the fear of failure and the unavailability of ICT facilities. Msila (2015) realized that younger teachers are more adaptive to change than older teachers, who are disappointed by the introduction of ICT. Majority of the young teachers in Kenya have the responsibility of introducing technology integration in learning processes since most of them have computer literacy and have a constructive insolence towards using IT in the instruction processes available compared to their age mates.

The ideologies of the physics teacher are reflected in the school teaching session (Ertmer and Ottenbreit-Leftwich, 2010). The beliefs of the educators about the learner-centred technique in most situations about the classroom actions do not penetrate classroom learning, and as a result, not all of them will accommodate technology introduction on the same plane, depending on their own nature. The shift in the attitude of the teachers can be helped by the collaboration and peer-teaching of the physics teachers, which will stimulate the tutors to change towards IT integration and professionally apply it in the classroom. It is when the physics teachers adopt a positive attitude in the teaching process that they gradually incorporate ICT in the field of instruction. The inability to implement ICT in the classroom depends on the attitude of the teacher, his/her competence in ICT /their beliefs and confidence about the use of technologies, and his/her interest in the sphere.

2.5.6 Readiness of Physics Teachers in Using ICT

According to the study done by Godoe and Johansen (2012), the teachers were not hesitant to employ technology, but most of them felt that the introduction of the technology would not contribute much to the learning process. It is the variables of willingness, perception, awareness, and critical thinking that the variables entail the factors of teachers that make them prepared to incorporate ICT in education. The teacher is an aspect that can be involved to prepare the educator psychologically to integrate the ICT. Al-Awidi and Aldhafeeri (2017) classified the application of technologies in the following categories: pioneers, sceptics, explorers, paranoids, and laggards. The physics teachers in secondary schools have been classified into such categories that include the teachers who practice ICT and those that do not trust the usage of communication technologies in the education sector.

It is also closely associated with the perception of the instructors towards the concept of the introduction of ICT (Rogers, 2003; Rogers and Finlayson, 2004). The Actual Usage of Technology (AUT) paradigm defines the readiness of the instructors to apply technology as a tool of the education process. The physics teachers are expected to make use of the technology to enhance their professional growth of the teacher. It is also expected that the physics teachers will embrace the technological changes meant to improve the teaching processes, as opposed to considering them as a penalty or a tool for the unemployment threat in the country. The attitude of the teacher, the utility of technology, and compatibility will play a significant role in determining whether this teacher will embrace technology. It is the attitude of the teachers that is important in determining whether they will be willing to adapt technology in the classroom.

The most important players in bringing any sort of global change in education are the teachers. Confidence is the critical element of integrating technology in education that is the dependent variable, which is tied to the teacher. Most teachers lack confidence, and hence they are fleeing from adopting technology in the learning process. Some teachers are very resistant to change, whereas in Kenya, the teachers, when introduced to the technology, lack the confidence to use the technology because they have no support or advice on the kind of tools to be adopted in the classroom. Rogers and Finlayson (2004) do not find much worth in the implementation of technology in the educational sector, as illustrated by teachers. The studies regarding the usage of techno tools in education have constantly demonstrated that it improves the standard and quality of the educational results. In her research regarding the thinking of secondary teachers in Tanzania in the context of using ICT in education (Mwila, 2018), the author has found that not only are men enthusiastic about using technology in education, but women are as well. The survey determined that the attitude of the teachers and learners concerning the use of IT is good. The issue of self-efficacy is exceptionally linked to the views of educators concerning the application of IT during the process of teaching. According to Korte and Husing (2007), the proportion of instructors in Latvia who had used IT in the previous year was 35 percent compared to 96 percent of teachers in the United Kingdom who used ICT.

The research found that a large percentage of school teacher are not aware of the importance of implementing ICT for the benefit of students. Fifty percent of teachers who participated in the netbook survey in the UK indicated that the use of technology would translate to an extensive workload (EU Schoolnet, 2010). The attitude of a teacher embracing technology in teaching is seriously addressed and influenced by their attitude and the observable reactions of students. In his research about the "*attitudes of Indian teachers to the application of ICT in the UAE classroom*", Bindu (2017) found that the lack of skills and competencies was a serious inhibiting factor despite the willingness of the tutors towards the usage of communication technologies.

2.6 The Role and Qualification of Physics Teachers in Kenya

2.6.1 Introduction

The study by Wahyuni et al., (2019) explained that the teacher must have relevant qualifications and prerequisite physics pedagogy for the effective delivery of physics content in the classroom. The report by the Ministry of Education (2019) shows that the Kenyan education system of 8.4.4 (Eight years at the primary level, four years at the secondary level, and four years at the University level) is faced with an acute shortage of physics teachers, and some have employed untrained form four leavers to teach physics. The untrained teacher might not have the prerequisite pedagogies that are integrated with relevant technologies to enhance efficiency in lesson delivery. The section discusses the roles and qualifications of physics tutors in learning institutions and the teacher-related factors that might be inhibiting physics teachers from integrating technology in the instruction process.

2.6.2 The Qualities of a Competent Physics Teacher

The qualities of a qualified and competent physics teacher include good mastery of physics content, effective communication, collaboration, listening, fluent speaking, adaptability, patience, and empathy. These qualities are nurtured as the prospective teacher undergoes training at the teacher training college or university level (Angell *et al*., 2004). A significant proportion of the Kenyan physics teachers have good qualities for teaching, but some of them lack the qualities of adapting to the new dynamic world of technology to help in improving classroom content delivery. Akanbi et al. (2018) note that the 21st-century teacher needs to be knowledgeable on how to use Communication Technology (CT) devices for effective lesson delivery, as compared to the traditional physics teacher who is believed to be the sole proprietor of physics knowledge.

Further, Akanbi et al. (2018) noted that the current physics teacher must be a knowledge facilitator and not a knowledge transmitter to guide students in acquiring the correct physics content using the appropriate teaching methods. The 21st-century physics teacher is expected to be loving, enthusiastic, warm, caring, and motivating to the learners for them to aspire to love the subject. In contrast, most physics teachers do not have these virtues of teaching physics, making the students fear the subject as well as the teacher himself.

Most physics teachers do not have learner-centred approaches, resulting in few learners registering for physics examination at the form four level due to the difficulty nature of how the physics subject has been taught. Masrifah et al. (2019) noted that the absence of good qualities among physics teachers dates to their training background, such that most of them are not trained and armed with the necessary pedagogy attributes to ensure they efficiently embrace the subject and be able to transmit the physics knowledge to the next generation. The study by Ingersoll (1999), as cited by Dee and Jacob (2012), found that it was normal to find physics teachers who have excelled well in the training process but are not able to deliver or transmit the same physics knowledge to their students. A significant number of physics teachers exhibit unfavourable instruction conditions to the learners, such that learners are not able to ask questions during the teaching process due to fear of victimization and intimidation. Wesonga et al. (2009) noted that most physics teachers in Kenya at the secondary level are feared by their students because of their personality attributes exhibited by them and inefficient training, which leads to poor teaching methodologies.

Competent physics teachers can provide a firm foundation for physics learners and encourage the majority of them to participate in selecting physics as one of their favourite subjects, as discussed in the study by Jones and Doolittle (2017). The link between the physics teacher and the student should be mutually exclusive, such that the students can seek clarification from the physics teacher, and the teacher can effectively evaluate the lesson delivered by the class by using formative and summative assessments (Adeyemo, 2010). Physics teachers with 21st-century skills have a varied choice of instructional strategies and participate in an extensive range of educational committees that influence to the overall management of the school. The knowledge of the physics teacher is essential in contributing to the success of the learners and the overall performance of the school. Therefore, the physics teacher must be effectively trained in pedagogies that involve ICT integration in education, as well as the educational management courses that would help them manage the emerging issues in the school. The study of Musau and Migosi (2015) emphasized that physics classroom management depends on the competencies and skills of the physics teacher in organizing the class, such that if the teacher is effective in class control, then there will be effective learning taking place. A teacher with an effective classroom management system can control the class and instil discipline among the learners without the use of intimidation and harassment, but through effective communication and collaboration to enhance constructive learning.

Effective classroom learning enables the teacher to build confidence and communicate effectively by invoking a participatory approach for all the learners to contribute to the learning process. The study of Musau and Migosi (2015) further noted that effective classroom management is greatly affected by the individual teacher's psychological characteristics that should have been nurtured during the training process. It was noted that a significant proportion of physics tutors in Kenya do not engage learners in the instruction process, and therefore, learners are left on their own to fill in the missing information.

The physics teacher training framework is very important in equipping physics trainees with the prerequisite knowledge that is very important to nurture 21^{st}-century learners with ICT integration skills. The selection of physics subjects among the three sciences greatly depends on the teacher's competencies, which motivate learners to love the subject. Muchira (2013) noted that learners would tend to select physics based on the qualities of the teachers and the method used for instruction. The majority of the physics tutors use a teacher-centred approach in the instruction process instead of a learner-centred approach; hence, they believe that learners might not have prior knowledge before the physics lesson is taught (Mulambe and Ongeti, 2017). The current physics teacher must have ICT skills to integrate into the pedagogy process to infuse hands-on skills among learners and deliver physics lessons using a variety of teaching strategies that intrinsically motivate learners.

In addition, the study by Mulambe and Ongeti (2017) found that the majority of schools in the country either have one physics teacher or some don`t have any physics teacher, hence they do not even offer physics in the secondary curriculum, which should not be the case as per the guidelines of the Ministry of Education in Kenya. The physics teacher should critically analyse the learners' desires and design lessons that are customized to the learners' needs and curriculum demands. Ngetich et al. (2014) emphasized that the physics teacher needs to master the content and have a variety of teaching strategies that are critical to effective lesson delivery by stimulating and developing learners' interest. The major function of the physics teacher is to ensure that each learner's potential is nurtured, and the student achieves their academic performance in physics, meriting their list of subjects.

2.6.3 The Professional Qualifications of Physics Teachers

The study by Badmus *et al*. (2022) on the "*Analysis of Ordinary and Advanced Level in-field Physics Teachers' Qualification, Experience and Job Placement in Indonesia*" emphasized that the academic qualification of physics teachers is very important in ensuring that the potential teacher has the pre-requisite knowledge of delivering physics lessons effectively. If the physics teacher is not qualified to teach the subject, it would be difficult for the teacher to master the physics content and use appropriate strategies for lesson delivery; hence, the learners would be more disadvantaged. The study by Murray et al. (2010) suggested that physics learners do not perform well due to being taught by untrained and incompetent physics teachers in the schools. When physics students are taught by incompetent teachers, it becomes difficult for them to grasp any physics content simply because the teacher does not know how to effectively deliver the lesson. It is not just that the physics teacher needs to achieve high academic qualifications to be effective in classroom delivery, but having a good mastery of the content is essential (Njiru and Karuku 2015).

The adaptation of effective methods of instruction so that abstract content can be taught in a more simplified way for the learners to understand is the major objective of the competent teacher. The systematic breaking down of the physics content into manageable chunks is a very critical skill that the physics teacher must have to effectively stimulate interest in learning among the physics students.

A competent physics teacher would use simple and precise language during lesson delivery to ensure that the learners admire to be taught the lessons up to the completion without having difficulties in mastering the physics terminologies and concepts. The academic qualification for physics teachers varies across the world. Meltzer and Otero (2014) highlighted that in the USA, for one to become a physics teacher, they must have a bachelor's degree and be a registered member of the American Physical Society (APS) or the Institute of Physics (IoP). The government of America encourages physics teachers to pursue master's or doctoral degrees for them to become competent teachers. Master's and doctoral degrees are highly valued in America and help physics trainees to become research-oriented scholars.

The qualification of a bachelor in America only enables one to teach in high school, but more qualifications, like master's and doctorate degrees, enable physics tutors to teach at the college or university level. The physics teacher needs to have other credentials, like a license to practice teaching in America. Polezhaev et al. (2017) highlighted that the application process for American residents to become physics teachers involves the submission of official university transcripts to the American Board, scrutiny of the submitted academic documents, and passing of the aptitude test offered by the Professional Teaching Knowledge Examination Board and American Board of Physics Examination. The American Board of Physics Examination prepares physics teachers for the new anticipated career in the teaching profession that starts with lesson preparation and the evaluation of the lesson objectives.

In Finland, a master's degree is a key requirement for one to be selected for the teaching profession. The physics prospective teachers must have covered at least 60 or 120 credit hours studying the physics content and pedagogical skills. The teaching practice in Finland is mandatory for candidates to be qualified for the certification process. The education program in Finland is research-based, and the teacher trainees must have acquired research-based skills to enable them to teach in high schools. According to the study by Sahlberg (2013), the degree programs take at least 5 years to complete, with two laboratory courses that equip the teacher trainees with hands-on skills for conducting experiments during the teaching process. Physics teachers in the comprehensive category of education from Grades 1 to 9 are supposed to have

60 credit hours, while those in the upper secondary are supposed to have 120 credits. The pedagogical studies program is undertaken by the teacher trainees as a separate program, and the teacher trainees must have covered and successfully completed degree programs.

The study conducted by Leinonen et al. (2020) on "*Finnish graduated physics teachers' views about their teacher education program: The disparity between the needs and delivery*" found that physics teachers were of the view that content knowledge and physical knowledge structures were adequately addressed during their training period. The major challenge observed by the physics teacher was conclusively addressing pedagogical knowledge content among the physics teachers, which is important for lesson delivery. In Africa, Kapngero (2018) observed that physics teachers are supposed to have a professional academic qualification of a bachelor's degree or higher Diploma for them to be allowed to teach physics at high school.

In Rwanda, physics teachers are required to have three years of teaching experience in addition to a bachelor's degree in order to join the teaching profession on permanent and pensionable terms. In South Africa, there are two routes one can use to become a competent, qualified physics teacher. The teacher needs a four-year bachelor's degree, or a three to four-year bachelor's degree followed by a Postgraduate Certificate in Education (PGCE). The Department of Education in South Africa shows that there is a high demand for STEM subjects, and therefore, more qualified teachers are required in the teaching profession to address the acute shortage of teachers. There is a need for colleges and universities to train more STEM teachers to fill the gap in the shortage of teachers to improve learning.

In Kenya, there is no significant difference in the prerequisite professional qualifications required for recruiting physics teachers into the education programs as compared to other developing African countries. The Teachers Service Commission (TSC) is entitled by the constitution of Kenya (2010) as the only independent institution mandated to carry out functions related to the management of teachers in the country, as outlined in the Kenyan law

(2013). For recruitment purposes with the TSC, the physics teacher must have a bachelor's degree in education or a bachelor's degree with a Postgraduate Certificate of Education. The physics teachers are trained by Teachers Training Colleges (TTC) and Universities to ensure they cover the required content and pedagogies for the teaching profession. For the students to be selected to go to the teacher training colleges for the secondary option, the prospective students must have attained a minimum grade of C+ in the physics subject and an overall grade of C+ at O-level or Form four levels. There are very few students who register and sit for the KCSE and the few who exit secondary schooling with good grades in Physics select other professions that require the physics subject for the training, as compared to the few who select education programs at the University level.

2.6.4 The Provision of Physics Education and the Scarcity of Physics Teachers

The Kenyan government, through the Ministry of Education, Science, and Technology, should invest in quality training programs for physics teacher trainees and offer incentives or scholarships to prospective students who wish to pursue physics courses at the university level. The universities should be equipped with the necessary infrastructure to ensure that physics students are pragmatic in terms of constructing their knowledge in solving daily problems. Krumphals and Haagen-Schützenhöfer (2021) emphasized that hands-on practical skills with the integration of technology are very important for both students at high school and at the university levels in achieving learning outcomes. Physics education should be given the priority it deserves in most schools across the world. It is normal in African schools for very few students to select physics at the form three level of education, and extremely few students to select physics at the university level. The notion that physics is a very difficult subject, and an abstract subject, has greatly reduced the number of candidates registering for the Form Four physics examination (MoE, 2017). There is a need for a change of attitude for both the physics tutors to ensure the methods of instruction are learner-friendly, to motivate the students to develop a positive appreciate the subject.

Musau and Migosi (2015) found that the ongoing professional development of physics tutors are not consistent with the number of physics teachers exiting the profession, since more physics teachers are leaving the profession looking for more lucrative jobs. Leveraging ICT devices would greatly help physics teachers to conduct virtual experiments to enable more students to access physics education. The usage of appropriate IT tools in the education procedure is very important in making abstract concepts simpler for learners to comprehend and understand, with the provision of virtual experiments. In Kenya, there are regional disparities in the number of physics teachers per school, with rural schools having a greater shortage as compared to urban schools. The government report of the United States of America (USA) (2022) on "*Nation at Risk: The Imperative for Educational Reform"* shows that the outbreak of COVID-19 intensified the acute shortage of physics teachers across the nation.

The report revealed that the USA high schools were lacking over 27,000 physics teachers, making it hard for learners to have a favourable schooling environment with the help of physics teachers. According to the report by the Statistical Research Centre of the American Institute of Physics (2022), the shortage of physics teachers across the nation is greatly affecting the quality of physics education, with learners opting to select other subjects instead of physics at the senior stage (Porter & Mulvey, 2022). The report of the institute shows that there is no shortage of biology teachers. The study by Smith and Doe (2022) at the Colorado School revealed that more than half the college physics students expressed interest in teaching high school, but the faculty assumed that the students were uninterested. The government of America offers student loan forgiveness programs and scholarships in mathematics and physics subjects to motivate students in selecting physics as their preferred subject for training.

Physics teachers in the USA are hoping for better remuneration, respect, and better opportunities for teaching using integrated technologies as discussed in the study by Meltzer & Otero (2014). In England, it is estimated that around 400 schools don't have physics teachers, especially in A- A-level secondary schools, and there is a need for the England government to employ more teachers to avoid creating a crisis in physics education. The study by Buabeng et al. (2015) established that the government of the United Kingdom has provided a scholarship for students pursuing physics courses at universities and encouraged more students to select physics at higher institutions of learning. It has been noted that physics teachers in England are exiting the teaching profession at a higher rate due to a high number of contact hours with the students, teaching multiple science subjects, and in search of lucrative salary employment opportunities. The report by the Institute of Physics (2022) entitled "*Unlocking the potential of Physics Skills in the UK and Ireland*" shows that if the scarcity of physics tutors in learning institutions is not addressed immediately by hiring more physics teachers, the issue would be compounded, and the problem will escalate and become more pronounced. The physics teachers who were interviewed in the Institute of Physics (2022) report indicated that competitive remuneration is the major drawback to the massive exit of many teachers to other professionals who have competitive remuneration packages.

In Kenya, the majority of secondary schools across the country don't have adequate physics teachers. The few schools that have physics teachers only have one teacher for the physics subject, which greatly affects the quality of lesson delivery and the instruction process. The inquiry by Okuno et al. (2015) explained that the Teachers Service Commission (TSC) introduced satellite lessons that are conducted in a specified school but broadcast to other schools with similar technologies, making it better for the other schools to have the same lessons as the initial school. The broadcasting of physics lessons through the local media and internet platforms has enabled some schools to access the required instruction even if they don't have a qualified physics teacher. Owolabi and Adedayo (2012) found that the lack of ICT infrastructure and poor internet connectivity have made it difficult for remote schools to access physics lessons via the local media and internet platforms. Further, Owolabi and Adedayo explained that mathematics is the building block of physics, such that physics teachers can use mathematical knowledge to construct the physics content and theories.

If physics students have a firm foundation in mathematics skills, then they also have an added advantage in the acquisition and mastery of physics concepts. Physics teachers are highly encouraged to use modern methods of instruction incorporated with technology to stimulate and motivate learners. Mwanaszumbah (2021) and Oyoo (2009) discussed that the use of Communication Technology (CT) makes physics concepts easy by using images and diagrams for visualization. The technology provides an array of resources for the physics teacher to select from making the lesson more interesting and engaging. The online linkage of the physics teachers through the stock exchange greatly motivates the learners as well as the teachers since they can share resources.

The Ministry of Education, Science, and Technology needs to continue the training of more physics teachers on the acquisition of new teaching skills that are relevant to the emerging technologies that influence human life positively. Reski et al. (2020) cautioned that learners are also moving with greater speed in the process of acquisition of relevant knowledge from the internet and social media platforms, and this makes the teacher improve on the acquisition process of knowledge to be in per with the physics students. The availability of the internet in the country has made it easier for learners to access knowledge and even question the knowledge of the physics teacher. The physics teacher should make use of the available ICT resources to be equipped with relevant skills for the facilitation of the instruction procedures.

2.7 Interactive Technologies in Teaching Physics: Authentic Learning Practices

2.7.1 Introduction

The application of interactive media in the instruction of physics has greatly changed the method of teaching. The interactive technologies produce real learning practices and instil 21st-century skills. According to the article by Anand (2015), the change in the art of instruction has become a large issue of concern for teachers. Towards the learner-centered approach, physics teachers have never stopped testing innovative teaching methods, novel pedagogies, and novel materials that embrace interactive technologies. The shift in the traditional mode of instruction is to nurture the capabilities of the learners that include critical thinking, problem-solving approaches, innovativeness, creativity, effective communication, and citizenship. This section is about the available interactive technologies in teaching physics and the actual learning practices that create 21st-century skills among learners of physics.

2.7.2 Interactive Technology in the Physics Instructions

The subject of physics is evolving at a very rapid rate across the globe, specifically in the developing countries where Information and Communication Technologies (ICTs) are well developed. Such facilities help to work intensively with interactive technologies, which is necessary in the process of modernizing education. This is because the cost and availability of technology-based devices are increasing the inclusion of interactive techno’s learning of physics, as it allows students to learn complex concepts in ways that are otherwise not achievable in the traditional approach of learning. The interactive technologies mentioned by Reski et al. (2020) develop the learner-centred approach, which allows the students to visualize the abstract concepts in a better way, collaborate, and receive immediate feedback.

The use of interactive tools in teaching physics in Africa, including Kenya, is limited, however, by many factors. Availability of appropriate technology equipment is among the greatest issues, as it might be too expensive. In addition, financial limitations are another problem for most schools and teachers in such regions, since they lack access to ICT tools. In case technology is a reality, the lack of technical competence of the secondary school teachers further becomes a barrier to its proper application. The other massive challenge is the negative attitude toward the technology adoption of both teachers and learners. These barriers should be overcome so that it is possible to implement interactive technologies in education more actively and to ensure that students can enjoy the innovations that contribute to the process of making physics more accessible and interactive.

Physics is one of the studies that provides a good foundation for technological advancement and invention. The majority of tools and processes that have transformed industries rely on principles of physics. The subject matter is inherently related to the development of technologies because its concepts and implementations make tools and procedures to be developed and applied to various industries. It is hence important that physics studies be updated according to the technology to ensure that the students are not only receiving the theoretical knowledge but also able to apply the knowledge they have gained to the current technological advancements.

Interactive technology is a technology that can be utilized to instigate two-way communication that entails a technology interface that can allow the individuals participating in the physics curriculum to be actively in the instruction process. This interaction may be of various types, such as educational software and applications among multimedia resources in the form of video lessons and electronically published books that can be actively learned. Interactive technologies do not only provide a delivery method of content, but they also alter the character of the learning process because they transform it to be more participatory and student-centred.

The essential role of interactive technologies in teaching is to engage the student such that he/she succeeds in becoming an active participant in the teaching process. This would generate improved creativity, critical thinking, and understanding. The interactive technologies offer a substitute to the traditional lecture model, where the focus is shifted towards the student-centred approach instead of the teacher-centred one. The students can study at their own pace, taking up areas they desire to take up, and they are encouraged to study as they are interested. This is a learner-centred and technology-based approach that is very interactive and, in most cases, more entertaining, which leads to a greater retention of information as well as a more entertaining learning process. One of the technologies that can be used to enhance this interactive experience is Computer-Assisted Instruction (CAI). CAI engages the students in the learning process by giving feedback, hints, and live presentations to solve the problems with the assistance of software.

CAI students have a chance to experience simulated physics that would replicate a physical phenomenon in the real world, giving them hands-on knowledge, but without physical materials. Lee and Welk (2021) found that in Kenya, only a quarter of sampled teachers engaged in interactive technology in the classroom, and this shows that most schools do not utilize technology well. Interactive technologies are very varied, including video conferencing devices and multimedia-based devices, and more advanced systems like intelligent tutoring systems. These tools are used to supplement the classroom tutor, and this makes the procedure of learning more interactive and individual. One such area is video conferencing, where the students may take up live demonstrations by professionals in distant places or other learners in other parts of the world. The lessons could be complemented with multimedia devices, including videos or animations, and simulations that could assist in achieving more abstract concepts of physics.

The COVID-19 virus accelerated the acceptance of various new educational technologies, including Big Data, Machine Learning, and the Internet of Things (IoT) across the world in 2020. These technologies have introduced new ways of accessing, processing, and even applying information in the education sector, particularly where, in the traditional classroom environment, there is a limitation of interaction in the classroom. The remote learning platforms turned out to be a crucial component of the pandemic education process and will be more commonly used in education after the pandemic. One is Big Data, which allows teachers to exploit the information on student performance to personalize the education procedures and the application of machine learning algorithms for provision of tailored feedback to improve the learning outcomes.

Emerging technologies, the relevance of internet connectivity, versatility and learner-centeredness in the field of training process are the issues of concern. According to Karl et al. (2019), interactive technologies that are blended in the physics instruction such as Augmented Reality (AR) and Virtual Reality (VR), collaborative learning environments and gamified learning environments are reshaping the learning process of complex subjects. These technologies can create a type of immersion that allows the students to familiarize themselves with the physics world in a virtual reality, touch the objects, and observe the phenomena that are otherwise unknown to them in a real classroom. Students can be put in a physics simulation where they have a first-person experience of the phenomenon and experiment, made possible by VR and AR, among others.

Another interactive technology that has been gaining momentum is mobile learning, through which students are able to complete the assignments and use their smartphones or tablets to access the course materials. Magda and Aslanian (2018) state that 46 percent of students in the USA would be ready to complete their coursework using mobile phones. This is more distinct in the present education design, where the students are becoming digital natives, and they have no qualms about using their mobile phones not only to play around but also to study through their mobile phones. Learning physics through mobile devices is more flexible and comfortable, as they are portable and can allow students to study learning content at any location and at any time.

The same trend of mobile learning is also being repeated in other regions. Cambridge Assessment International Education (2018) says that 80 percent of students in England would use mobile phones to do their assignments, which again proves the prevalence of mobile-based education occurring in the world. Mobiles also give a chance of microlearning that involves showcasing the content in small, manageable bits that are more easily understood and remembered by learners. This strategy reduces the cognitive load and improves retention, and it is especially successful in cases of learning subjects like physics, which are often linked with complex concepts and formulas.

Interactive whiteboards constitute the other useful tools in the interactive classroom. These boards enable the teacher to arrange the discussions in the form of small groups, round tables, and collaborative projects, and these assignments promote more activity and understanding among students. According to Cambridge Assessment International Education (2018), one out of three learners globally have, in one way or another, been exposed to a smartboard in the classroom. Using these boards, the teachers are able to display interactive simulations, diagrams, and videos as well as provide the students with a visual-tactile experience in interacting with the material. The projections of the market indicate that the increasing popularity of interactive whiteboards can be observed; as Markets and Markets (2018) estimated, the market of interactive whiteboards will reach 5.16 billion dollars in 2023. Based on this trend, it is noteworthy that countries like Kenya should invest in interactive whiteboards to motivate students and make the learning activities more enjoyable.

To make Gen Z interested in physics, teachers must resort to the interactive tools they have. Gamification has served as an extremely powerful tool for maintaining the interests of the students in the learning of subjects that can be deemed as being difficult or abstract, such as physics. Gamification refers to the process of integrating games' qualities and principles into the learning process that involves leaderboards, challenges, and points. As Sailer and Homner (2020) indicate, the inquiry conducted by Deterding et al. (2011) found that gamification can improve the retention rates and motivate students to learn the content. Making physics a game will make it less threatening and enjoyable to use games, thus scoring higher in terms of engagement and results.

It was also stated by the National Centre of Education Statistics (2019) that gamification positively affected the reduction in the number of dropouts in learning institutions, and the number of dropouts dropped from 4.7 to 3.5 percent in schools where students are provided with gamified learning devices. Gamification can also be a good way to introduce some of the more complex concepts in physics learning, where a student is asked to solve some problems and make some progress through some levels as part of a game. To illustrate, the students may participate in a virtual physics contest, where they are able to apply the laws of motion, energy, and force to get points.

This not only aids in reinforcing the knowledge that is learned in theory, but it also gives the students some sense of success. Although it is rather clear that interactive technologies provide numerous advantages to the educational process, their use is based on numerous challenges. One of the major problems is the possibility of distraction. Students are distracted by social media and other non-educational applications; it is not always possible to pay attention when students are working with digital devices. The problem of digital distraction, as pointed out by McCoy (2016), is increasingly growing worrisome, and the author notes that teachers must find a way to ensure that the information is not distracting them, and instead, they are listening to the learning process.

Trying to combat this issue, many educators have turned to experiential learning, in which practical and practical experiences are considered. The experience of learning helps the students to apply what they have acquired in the real world, thus making the process of learning meaningful and easier to remember. For example, students may be requested to perform a physics experiment with the help of the interactive technology, e.g., a virtual laboratory or a simulation. The information is more likely to stick in the minds of the students as well as to make them find its relevance in terms of their life experiences.

2.7.3 Authentic Learning for Nurturing Learners with 21st Century Skills

It is in this that Lombardi and Oblinger (2007) consider authentic learning as the active learner-based learning where the learner is not compelled to memorize and practice them during the examinations. The genuine learning will render the learning pertinent to the personal experience of the learners and connect the learning acquired to the actual world. It specializes in the development of practical, real, and quality learning products, especially in physical courses where experiments and problem-solving can be implemented in a practical approach in an effort to come up with a high-quality understanding of a subject. Authentic learning helps learners to achieve the skills that can enable them to survive in a more complex and dynamic world. This kind of plan will motivate the learners to transfer the skills taught in physical science to realistic and everyday issues, which, in their turn, will render the learning process meaningful and unforgettable (Herrington et al., 2014).

However, traditional methods of teaching are passive in nature, where the students do not participate in the process of learning, but they are consumers of the knowledge they get. This passive style of teaching process will tend to resemble physics, which is more abstract to teach, hence leading to a lack of student interaction. The authentic learning approach entails a personalized style of learning and hence enables the learner to achieve competencies in the long run. It is also very useful, particularly in teaching physics, where periodic experimentation and low-stakes tests, as well as discussion that may occur throughout the course, offer the scaffolding that the learners require in bridging the theory and practice gap. According to Campbell and Kent (2010), the problems that are in the real world should be included in the curriculum to ensure that the students are equipped with knowledge of being able to think critically and problem-solve issues that are inherent in the current labour market.

Conventional learning is mostly teacher-centred and in the form of a strict hierarchical system in which the teacher is the sender and the student the receiver, and the latter later vomits the information of the sender and consequently applies it in a test. In this type of passive learning, there is no chance for the learners to apply the material in any manner that would render it real-life.

This is among the reasons why students cannot retain anything, as in traditional classrooms, there is no multisensory interaction. Among such topics is physics, which requires real-life experiences, and the students can touch and feel the things they are studying. They deny the learners a chance to learn the concepts, as they do not give them an opportunity to apply the concepts to the way they experience (Lombardi and Oblanger, 2007). This has resulted in the loss of several contents once the students are out of the classroom, since they have not been able to interact with the content purposefully.

The conventional teaching approaches cannot prepare the students to deal with the dynamic and fast-evolving industrial world in the 21st century, where innovation, analytical thinking, teamwork, and problematic-solving have become prominent. According to McPeck (2016), the modern requirements of the educational practice are oriented to this high level of thinking skills, since nowadays it is recognized that only being able to memorize and regurgitate the facts, one will not be able to achieve much success in the modern environment.

It is up to the physics classroom to learn to adapt to such changes, not necessarily based on the passive nature of learning, but on experiencing true-life learning, which is more realistic and experiential for the acquisition of deeper learning and skill.

One of the most important peculiarities of real learning is the 21st-century skills development. Collaborative, communication, creativity and critical thinking skills are the 21^{st}-century skills that will make the students successful in the world, which is becoming complex and quite interconnected. Real-life learning makes the student challenge the curriculum that he is learning, since the student would have a better idea of how what he is learning can be applied in the world around him. The real learning aims at ensuring that students survive beyond the classroom rather than merely equipping them to come out of the test (Koedinger et al., 2015).

The fact that intrinsic motivation is also employed is also an important element of genuine learning, as students will work with the material because they want to learn and not due to the coercion of grades or any other incentive. Intrinsic motivation will initiate the learners to engage in the understanding procedures and will prompt them to work on more difficult tasks and study the material more deeply. In a case in point, an intrinsically motivated learner of physics may opt to investigate what is not covered in the classroom curriculum and carry out his/her own experiment or research into how theories that s/he is studying are being applied in real life (Lombardi and Oblanger, 2007).

As Koedinger et al. (2015) explain, the physics teacher is not only the one who presents the students with material, but he/she also offers the latter options of how to experiment, touch, and make personal associations with the presented material. In this way, there is enhanced understanding, and the students can remember well. Learning in its true form also demands that students be able to apply whatever they are learning in the classroom in order to solve real-life problems. The new technology in the form of virtual simulation, augmented reality (AR), and artificial intelligence (AI) gives the students a chance to understand how to investigate complicated problems under a controlled setting. Students can visualize information using these technologies and interact with it, simulating various variables and how their choices affect them in real-time. This could be the case of a physics lecture where the students could be provided with a simulation where they could experiment on the effect of varying quantities of force on the motion of a body, and this would bring them closer to knowing the laws of motion as propounded by Newton (Gerlach, 1994).

The technologies are not only beneficial to the study process, but they also equip the students with the type of problem-solving that they would be required to engage in in their careers. The true learning principle is based on the principle of constructivist theory that presupposes all learning processes as based on the assumption that learners are forming knowledge by having interactions with the surrounding environment and also forming a sense of the world around them. Social constructivism mocks the notion that learning can be done passively through exposure to information, but it also stresses the notion that learning is direct, experience-based, and driven by personal experiences. They construct new knowledge actively as they elaborate on what they already know in coming to make relations between what they are studying and what they have already known. Gerlach (1994) describes constructivist learning as a social one (that is, it involves collaboration, communication, and exchange of ideas with other people).

Social constructivism is a theory that has dominated the field of education since the 1990s, especially in science and mathematics education. Constructivist strategies that could be applied to teach physics include offering the students a problem to solve and testing hypotheses and experiencing working in chemistry. This is unlike the traditional practices of majoring in rote learning and memorizing. No one must memorize the formulas within a constructivist classroom, and in fact, students may be requested to come up with their own experiments for testing the principles under which they are being taught (Campbell and Kent, 2010). This not only increases their knowledge but also results in critical thinking and creativity.

Social constructivism also places a lot of emphasis on collaboration in learning. The authentic learning model provides the students with a chance to collaborate as they find solutions to their problems and exchange and criticize one another in the process of thinking. This teamwork is a pointer that this is what happens in the real world, where teamwork and interaction are the key references to success among professionals. The group projects may also be considered one of the variants of group work within the classroom, whereby the students will be asked to plan an experiment and carry it out to address a problem in real life (Herrington et al., 2014). The teamwork will assist students in developing the capability to think critically and communicate, as well as being able to solve complex problems.

Although the use of such a method can be useful in the teaching of physics in Kenya, there exist considerable problems in the application of authentic learning in teaching physics. One of the major problems is the excessive focus on memorization and examination preparation. A significant proportion of schools get to know how to memorize the concepts of physics and its formulae and graduate exams instead of learning and implementing the concepts into practice (McPeck, 2016). Due to this, the students can pass their examinations but fail to apply their knowledge practically.

Such an approach not only holds down the knowledge of the physics of the students but also does not equip the students to address the demands of the modern-day workforce. The issue of standardized testing is of great concern in Kenyan education, like most other educational systems. Unlike exams, which are a highly empowering method of assessing the learning of students, they will tend to promote superficial learning, unlike deep learning of the issue. Rather, the actual learning is devoted to assisting students in developing skills that will enable them to pursue a solution to practical problems (Koedinger et al., 2015). This necessitates the abandonment of the traditional testing, and instead, the performance testing is carried out where the students are being tested on their capacity to implement what they learned in real-life scenarios.

The other problem in the implementation of authentic learning in Kenya is the problem of shortages of resources. Not all schools have the technology and materials required to facilitate the hands-on learning experiences. The teachers themselves, in certain cases, would need training or facilitation to enable them to be capable of applying real learning methods in the most effective way (McPeck, 2016). The gap can be narrowed down through the application of the new technology, like simulations and virtual laboratories, but these are generally quite costly and would need continuous internet connection, which is not easily found in underfunded or rural schools.

Nonetheless, as much as these are the challenges, there are certain opportunities for integrating authentic learning into the physics curriculum in Kenya and other developing countries with the help of the emerging interactive technologies. Increasingly, virtual reality, augmented reality, and artificial intelligence, among other technologies, are allowing students to learn more complex concepts more interactively and experientially. Such technology enables learners to learn the practical issues in the virtual laboratory, where they can experiment, err, and familiarize themselves with them without taking any risk, as they do in a conventional laboratory (Koedinger et al., 2015).

The VR simulations as an indicator can also bring the students to the environments in which they can conduct physics experiments that they cannot or cannot conduct in the real world, because it would not be safe. The variables of forces, mass, and velocity can also be manipulated in a virtual physics lab in a manner such that the students can see the way they influence the movement of an object. The learners are not subjected to undertaking the procedure of altering the settings of an experiment and can adjust the settings at a button press and immediately view the outcomes and adjust their plans (Herrington et al., 2014).

2.7.4 Interactive Technologies that support Authentic Learning

It is in this context that Lombardi and Oblinger (2007) perceive authentic learning to be the active learner-based learning where the learner is not compelled to memorize and practice them during the tests. The real learning will render the learning pertinent to the personal experience of the learners and interrelate the learning obtained to real life. It is committed to the development of realistic, concrete, and good learning products, especially in physical courses where experiments and problem-solving can be accomplished in a pragmatic approach, in a struggle to come up with a good quality cognition of a subject. The original learning helps the learners in achieving the skills that might help them to survive in a more complex and dynamic world. This approach will help to motivate the students to translate the acquired knowledge into real life and real-life problems, which, in their turn, will make them active participants of the learning process and consumers of the acquired knowledge (Herrington et al., 2014). The traditional ways of teaching are passive, however, which means that the learners will not be involved in the knowledge acquisition procedures, but they will be the consumers of the knowledge they will receive (Herrington et al., 2014).

This kind of teaching process is passive and will be more comparable to physics, which is more abstract to teach, and hence, there will be no interaction between the students. The authentic learning approach suggests a personal character of the learning process and, thus, enables the learner to develop competencies in a long-term perspective. It also proves to be useful, particularly when instructing physics, where periodic experimentation and low-stakes tests, and even discussion that can occur during the course, form the scaffolding that the learners require in bridging the gap between what is learnt in the classroom and industry application. Campbell and Kent (2010) believe that the real-life problems ought to be part of the curriculum as a measure of ensuring that the students are made aware that they can think critically and solve the problems that are inherent in the current labour market.

Conventional learning is majorly teacher-centered and in the nature of a strict hierarchical system, where the holder of the information in the form of the teacher acts as a sender, and the student is the recipient and thus later applies the information sent by the sender to a test. By this mode of passive learning, the learners lack a chance to demystify the contents in a manner that would make them real life. Speaking with more specifics, physics classes are abstract, and students do not understand how to apply rules and formulas in the real world, knowing them (McPeck, 2016). This also means that the members of the study will be more likely to pass the test, but they are not prepared to meet the real-world challenges, and they will not be inclined to show interest in the subject in the future, as there is no multisensory engagement in conventional classrooms.

These are subjects such as physics that entail real-life experience, and the students can touch and feel what they are studying. They deny the learners a chance to learn the concepts because they fail to give the learners a chance to transfer the concepts to the experiences that they undergo (Lombardi and Oblanger, 2007). This has contributed to the loss of some of the content once the students are no longer in the classroom, since they have been unable to learn the content purposefully on how to handle the dynamic and rapidly changing industrial world in the 21st century, where creativity, analytical thinking, teamwork and problematic-solving have become the order of the day. The contemporary needs of the educational practice are challenged on the level of the thinking skills since, at this point, it is already known that being capable of memorizing and regurgitating the facts, one will be unable to do much in the contemporary environment (McPeck, 2016).

The formation of the 21st-century skills, more real and experience-grounded, and, therefore, more aligned with the real learning and acquisition of deeper learning and skills, is one of the greatest peculiarities of real learning. The collaboration, communication, creativity and analytical thinking skills are the 21st-century abilities that will make the students successful in a world that is becoming complex and rather closely intertwined. Life learning will lead the student to raise doubts about the curriculum that he is following, since the student would be in a better position to see how what he is learning can be implemented in real life. Another crucial element of the real learning process is the fact that intrinsic motivations are also applied, as the students are interested in learning the material and not because grades or some other means of extrinsic motivations are imposed (Koedinger et al., 2015). The intrinsic motivation will provoke the students to appropriate the learning process and will induce them to work on more difficult tasks and cover the material more deeply.

A case in point here would be that an intrinsically motivated student in physics can decide to go out in search of what they are not being taught in the classroom curriculum and conduct his/her own experiment or research on how theories that s/he is studying are being implemented (Lombardi and Oblanger, 2007). The physics teacher is not only the one who imparts the material to the students, as it is discussed by Koedinger et al. (2015); he/she simply offers the latter the opportunities to experiment with the offered material, touch it, and develop personal associations. In this manner, there is a higher level of understanding, and the students are also capable of recalling whatever they are studying in the classroom to be applied in real life. The new technology in the form of virtual simulation, augmented reality (AR), and artificial intelligence (AI) will give the students a chance to study how to investigate complicated problems in a safe setting. The technologies enable students to visualize information and model various variables and the effect of their choices on them in real time. This can be during a physics lecture where the learners can be provided a simulation where they can experiment with the effects of varying measures of force on the movement of a body, and this would bring them closer to understanding the laws of movement as declared by Newton (Gerlach, 1994).

The technologies are not only beneficial to the learning process, but they also equip the students with the kind of problem-solving that they would be required to do in their professional lives, assuming that learners are constructing the knowledge based on the presumption that they are having interactions with the environment around them, as well as constructing a sense of the world around them. Social constructivism ridicules the passive mode of learning, which is presented as a result of being fed information, but pays greater attention to the process of learning, which is an experience and is motivated by personal experience. They build new knowledge by elaborating on what they know in the process of creating a relation between what they are studying and what they already know.

Social constructivism is also a social learning such that it requires collaboration, communication, and exchange of ideas with other individuals. Social constructivism, a theory, has dominated the academic field of education since the 1990s, especially in such fields as science and mathematics education. The constructivist approaches that could be adopted to teach physics include giving the learners a problem to be answered and experimental hypotheses, and experience in the sphere of chemistry. This goes against the conventional approaches of majoring in rote learning and memorizing. A constructivist classroom does not require memorizing any of the formulas, and in fact, students can be invited to engage in inventing their own experiments to check what principles they are studying (Campbell and Kent, 2010). This is not only causing them to be more knowledgeable, but it also results in critical thinking and creativity. Social constructivism also places a lot of emphasis on collaboration during learning. The real learning model gives the students a chance to support one another, not only to provide solutions to their problems but also to provide and criticize one another in the process of thinking.

This angle of team play is a pointer to the fact that this is what happens in the real world, where teamwork and interaction are the primary points of reference to success among professionals. The group projects might also be considered one of the variations of group work in the classroom, where students will be asked to conduct an experiment and apply it to address a real-life issue (Herrington et al., 2014). However, even though such an approach can be implemented in a positive way of teaching physics in Kenya, there are considerable problems with teaching physics by means of implementing the process of authentic learning. The excessive focus on memorizing and training for exams can be mentioned among the largest problems. Most of the schools are accustomed to memorizing the concepts of physics and formulae and taking exams at a graduate level instead of learning and applying the concepts in practice (McPeck, 2016). The students can pass their examinations due to this, but do not apply their knowledge in real life. This not only suffocates the learning of the physics of the students, but it also renders the students ill-equipped to serve the labour markets that are present in the day. The element of standardized testing is very crucial in the Kenyan education system, just as it is in most other educational systems. It will also be more concerned with surface learning instead of deep learning of the subject, like exams, which are a highly empowering method of establishing the level to which the students have learned.

Rather, the actual learning is employed to enable students to develop skills that would enable them to find the solution to the practical problems (Koedinger et al., 2015). This will demand the dropping of the traditional testing, and the performance testing is carried out, in which the students are tested on their capability to implement what they learned in a real-life scenario. The other problem with the application of authentic learning in Kenya is the problem of lack of resources. Not all schools do not have the technology and materials required to support the hands-on learning experiences. In other cases, the teachers themselves would also need training or facilitation to enable them to be competent in applying actual learning methods in the most appropriate way (McPeck, 2016).

This can be bridged to a gap with the use of the new technology, which is simulations and virtual laboratories, though they are normally very costly and will require constant access to the internet, which is hardly accessible in underfunded or even rural schools in Kenya. Increasingly, VR, AR and AI, among other interactive technologies, allow students to learn more intricate concepts more interactively and engagingly. Such technology, as an indicator, can help the students learn the practical issues in the virtual lab, where they can experiment, make mistakes, and acclimatize themselves to the physical, but they cannot or cannot do it in the real world since it would not be safe (Koedinger et al., 2015). The variables of forces, mass, and velocity can also be controlled in a virtual physics laboratory in such a fashion that the students can visualize the way that the forces, mass, and velocity affect the movement of an object.

2.8 Role of students' attitudes the adoption of ICT in physics instruction

2.8.1 Introduction

One of the important actors of technological applications in the teaching learning experience is the learners. Attitude is a judgement of a psychological object, which is predetermined by such features as favourable/unfavourable, agreeable/ disagreeable, or appealing/unappealing (Gastager, 2022). The children in the modern world are moving into technology, more so when they are compared to their teachers, who are yet to incorporate communication technology in classroom teaching. Positive perceptions can be used to increase the level of involvement in technology, the level of learning can be increased, and the educational process can be made more enriching, and vice versa. In physics, it can refer to the differences in the students' interest in employing simulations, internet resources, and interactive tools in the understanding of complex topics. Therefore, this study examines factors influencing the attitude of physics students towards ICT integration in the learning process as discussed in the subsequent section.

2.8.2 Factors influencing students’ attitudes toward the inclusion of IT in the instruction process

The students are mostly engaged in the process of creating the desirability of communication technologies when teaching physics. The major ones are perceived usefulness, ease of use, interest and motivation, and previous exposure and confidence. The majority of these learners are not doubtful and are likely to use ICT in learning physics since they have experience in technology in education (Godoe & Johansen, 2012). The attitude of students is crucial in the learning outcome as applied to the performance of ICT. It is likely that when the students are engaged, they would be more likely to be attentive and remember facts, and self-directed learning, and collaborative learning, and persevere in solving difficult physics problems using digital media. The negative emotions will nonetheless impair the performance of ICT, including resistance to change, technological anxiety, and perceived irrelevance. To improve the attitudes and usefulness of ICT, teachers ought to gradually and drastically shift in the lessons, orient or train in the usage of tools, demonstrate actual usage of physics by utilizing ICT, and enlist student input and contribution towards the selection of ICT tools that they prefer to utilize.

2.8.3 Students' Attitudes towards Technology in Physics Instruction

Assuming that the physics students are already positive about ICT use in education, then the attitude will enhance their interest in using it and exploring what it can do. This gives way to the emergence of enhanced comprehension of concepts, acuity in solving problems, and an increased desire to learn. Conversely, where the student is negative, then he or she will not yield to using ICT and will not exploit its benefits and will even reject using the ICT. This may result in decreased involvement, low achievement in learning, and low enjoyment of physics overall. Physics students can be oriented in various ways regarding the experience of simulations as a technique of visualizing complicated processes, working in virtual laboratories, or even communicating with each other via the internet. These perceptions usually affect their thought process regarding the application of technologies in the instruction procedures. Hinostroza (2017) argues that the antecedent aspects that influenced the behaviour of the physical science scholars towards the adoption of the communication technologies may include their previous experience with the same technology, their perception of its usefulness, and their self-efficacy through the use of the technology. Therefore, the role played by teachers is very important in determining the perceptions of learners. The teachers can develop positive attitudes and implement the use of IT by establishing a motivating and supportive learning environment, exemplifying the advantages of IT usage, and offering sufficient training and support.

On the one hand, in-class factors that include the pedagogical approaches, the availability of scientific materials, teacher influence, family factors, environmental influence, and gender may predetermine the disposition towards science subjects in schools. One is the fact that the high frequency of boys playing computer games is compared to that of girls due to their capability to manipulate technology. Badmus and Jita (2022) assert that there are more learning institutions that are likely to embrace the incorporation of technologies in the learning procedure since they improve accessibility, expand the relevance in the learning process, and foster equality among the learners. ICTs in learning have diversified the opportunities and access, as online teaching gives the students a personalized learning experience, as they can study the material in the comfort of their homes or place of work. The computer applications of Zoom and Google Meet, coupled with the pre-recorded teaching content on the memory cards and smart memory cards, have enhanced the imparting of technical courses such as welding and fabrication to the trainee.

Mwanda et al. (2017) examined the degree of commitment of the students in the learning of the Biology subject by introducing the use in the Rachuonyo South Sub-County. The study adopted a Likert scale of 1 to 5, where the former indicated strong disagreement and the latter strong agreement on the commitment to learning with the use of IT integration. The results of the study revealed a 4 score, which implied that learners were more committed to attending classes during the cases where ICTs were employed to impart biological subjects. Scholars have also identified positive attitudes and a high usage of techno devices as a result of effective instruction. As an indication, another study by Waigera et al. (2020) had a hypothesis of high impact of believing and trusting of using technology. Moreover, adverse feelings were revealed in the poor inclusion of interactive media in education. In summary, the students' attitudes towards ICT are a matter of serious consideration that will determine the effectiveness of the same application in the physics classroom. Positive attitudes trigger better engagement, improved learning and even the entire process of education, whereas adverse attitudes may inhibit the adoption and performance.

2.8.4 Summary of the Literature Review

This chapter reviewed information related to the usage ICT in the education and its significant potential to impact the quality of physics instruction at the secondary school level. As pointed out from the in the reviewed literature, the use of animations, virtual labs, multimedia resources, and interactive learning environments, the use of ICT can enhance learners’ conceptual understanding, increase motivation and engagement, and strengthen problem-solving skills. The educational theories reviewed, namely Behaviourism, Cognitivism, Social Constructivism, and the “*Technological Pedagogical Content Knowledge (TPACK) framework*”, provide a strong foundation for understanding how ICT can support effective Physics instruction. These theories emphasize active learner participation, knowledge construction, cognitive development, and the meaningful integration of technology, pedagogy, and content knowledge in the learning process (Mishra & Koehler, 2006; Sweller et al., 2020; Rigopouli, 2025).

Despite the increasing volume of research on ICT integration in education, several important gaps emerged from the reviewed literature. First, many studies have examined ICT integration in education generally or within science education, with relatively little attention given specifically to Physics instruction in Kenyan secondary schools (Hegedus et al., 2017; Getahun et al., 2026). Given the abstract nature of many Physics concepts and the subject's strong dependence on experimentation, there is a need for studies that focus specifically on how ICT can support Physics instruction in Kenya.

Second, although the importance of ICT infrastructure and digital resources in enhancing instruction has been widely acknowledged, there is limited empirical evidence regarding the types of ICT resources available, accessible, and utilized by Physics teachers in secondary schools in Kenya (Karanji, 2018; KNBS, 2019). Existing studies point to disparities in ICT access among schools and regions but provide limited insight into how these differences influence classroom instruction in Physics. Third, while learner-centred and technology-supported pedagogies have been widely promoted in the literature, there is insufficient evidence on the specific ICT-integrated instructional strategies employed by Physics teachers and the extent to which these strategies are implemented in classroom practice (Ramaila, 2024; Bao & Koenig, 2019). As a result, there remains limited understanding of how teachers transform available ICT resources into effective instructional approaches for teaching complex Physics concepts.

Fourth, teacher-related factors such as attitudes, beliefs, competence, and confidence have consistently been identified as key determinants of ICT adoption (Goldhaber et al., 2021;

Omariba, 2024). However, previous studies have reported mixed findings regarding the extent to which teachers' attitudes influence the actual integration of ICT in Physics instruction, particularly in schools where ICT infrastructure is already available. This suggests the need for further investigation into the role of teachers' attitudes in promoting or hindering ICT use in the classroom. Fifth, although learners are central participants in technology-enhanced learning, limited research has explored how students' attitudes, interest, self-efficacy, and willingness to use technology influence the successful integration of ICT in Physics classrooms (Godoe & Johansen, 2012; Badmus & Jita, 2022). Consequently, there is inadequate understanding of learner-related factors that may either facilitate or impede the effective usage of technology in learning.

In addition, much of the available literature has been conducted in developed countries where ICT infrastructure, teacher preparedness, and institutional support differ considerably from those found in developing countries such as Kenya (UNESCO, 2023; Ndemo & Weiss, 2017). As a result, findings from these studies may not fully reflect the realities and challenges experienced in Kenyan secondary schools, highlighting the need for context-specific research. The identified gaps are closely linked to the statement of the problem, which points to the persistently minimal of technology usage in Physics instruction despite substantial government investment in ICT infrastructure and supportive policy initiatives. Although ICT is widely recognized as a valuable tool for improving science education, there remains insufficient evidence regarding the availability and utilization of ICT resources, the instructional strategies adopted by Physics teachers, and the influence of both teacher and student attitudes on ICT integration in secondary schools. Therefore, the study sought to address these gaps by examining the ICT resources available for Physics instruction, the ICT-integrated instructional strategies employed by Physics teachers, and the influence of teachers' and students' attitudes on ICT integration in secondary schools.

CHAPTER THREE: RESEARCH METHOD

3.0 Introduction

This chapter discusses the investigative method used in this study. According to Patten (2016), "*research methods are systematic strategies used to gather, analyse, and interpret data to answer research questions or test hypotheses*". They present methodical coverage of research and are therefore valid, dependable and replicable. These methods can be qualitative and quantitative and can also be mixed, which can incorporate a combination of both. Qualitative approaches centre on the exposition of subjective experiences, meanings and perceptions through interviews, focus groups, observations, and case studies. The quantitative approach includes quantification and measurement of data, the values of which are numerical, for instance surveys, experiments and statistics. The mixed methods are used to integrate the approaches of both qualitative and quantitative methods to obtain amore in depth analysis of the data collected in the investigation. According to Walliman (2021), the significance of the research methods is that they enable the researchers to guarantee the validity and reliability of the findings, offer a methodological procedure for the replication of the research, and help the researcher to draw a relevant conclusion and make decisions that are based on evidence. Some such research methods include surveys, experiments, observation, interviews, case studies, and content analysis.

The researcher in the study aims to investigate the determinates influencing the usage of ICT in physics instruction, adopted a mixed approach to the research questions with the view of collecting reliable information and constructing informed conclusions that could be made based on the acquired evidence. The mixed-method research design entails the incorporation of both numerical and textual data collection and analysis in the same study, with the benefit of the researcher reaping the benefits of both research methods to have greater insight into the concept being studied. The mixed-method approach was suitable for the study since the characteristics of the research questions that imposed the need to collect both numerical and non-numerical data in an effort to achieve rigor in the findings obtained.

The rationale for this study was to verify the determinants constraining the inclusion of technologies in physics instruction. The research objectives that guided the study were; 1) To assess the availability and utilisation of IT resources in secondary schools for physics instruction in Nairobi County, Kenya, 2) To assess the ICT integrated strategies for teaching Physics at the secondary school level, 3) To establish how the attitude of physics teachers affect the use of ICT in physics instruction and 4) To establish how the attitude of physics students affects the use of ICT in physics instruction. The development of information technologies has gradually changed the way physics is taught in secondary schools, especially in developed countries. It has revolutionized the way physics is taught from a teacher-centred approach to a learner-centred approach that transforms learners from passive to active participants.

The incorporation of digital devices in physics education possesses a significant potential to enhance acquisition of skills among the students. Nonetheless, in Kenya, particularly in the secondary schools within Nairobi County, ICT integration is still at a very low level of below 20% (MoE, 2022). The majority of secondary school teachers have not yet embraced technology for classroom instruction as a requirement by UNESCO (2022) for imparting the requisite competencies and skills among the students. The major obstacles inhibiting the integration of digital devices in schooling include infrastructural impediments that involve the absence of ICT resources such as laptops, computer laboratories, and internet connectivity, inadequate teacher training on Information and Communication Technology literacy, restricted access to digital resources, and adverse teachers' opinions of Physics as an esoteric and challenging subject.

Notwithstanding, national programs have advocated for the incorporation of information technology in education, but there has been a deterioration in both Physics performance and enrolment in secondary schools. It is estimated that between the years 2018 and 2020, the number of Physics candidates in Nairobi County decreased by 33.5%, while the average KCSE score declined by approximately 29%. This reduction is associated with ineffective instructional techniques, insufficiently educated teachers, and inadequate utilisation of Information and Communication Technologies.

The percentage of educators actively using ICT in the classroom to teach physics is rather high, and the large majority of them can ensure the most successful learning outcomes. The positionality of ICT resources in the public schools is also much lower than in the private ones, which has led to the inequality of education in the country. The study objective was to examine and discuss the most pressing challenges to the ICT application in teaching physics in Nairobi County and suggest remedies to facilitate the students ' involvement in the science subjects like Physics, Chemistry and Biological science subjects.

The inclusion of IT in physics instruction provides a platform to improve the understanding of abstract concepts and speed up the transfer of practical skills to learners. The government of Kenya has made a substantial investment in the provision of digital tools to learning institutions in order to improve the standards of education in Kenya. The country vision 2030 aims at transforming Kenya into an industrialized middle-income country that would offer the people a quality life. The African Agenda (2063) emphasizes the inclusion of digital devices in schools so as to achieve the quality education requirements. The establishment of policy on technology integration in education singles out capacity building among the teachers at all levels, good governance, and management of ICT tools as very critical to ensuring quality education (National ICT Policy, 2020). The policy emphasizes a framework to improve the digital economy and effectively boost services delivery among the Kenyan citizens.

According to the National ICT strategy for Education and Training (2018), there is a need for Kenya to address the challenges facing ICT integration in schools, such as inadequate computers that stood at the ratio of one computer to 150 students in Africa, while in Kenya, the ratio stood at one computer to 120 students. The ratio has changed over time with government initiatives to continuously support the provision of ICT tools to schools through public-private partnerships. For instance, the Ministry of Education started to provide tablets to primary learners through a program dubbed the Digital Literacy Programme (DLP) during the financial year of 2013/2014, but the program was not successful due to financial constraints (MoE, 2017). According to the needs assessment report for the development of policy on ICT in education and Training (2018), it was established that 76.8% of higher education institutions have access to ICT tools, but the percentage was low in special needs education colleges.

The Kenyan government has connected the majority of schools to the national electricity grid and the connection of fibre optic cable, but the number of computers that access the internet is still minimal. The study by the Ministry of Education (2020) established that access to digital tools in schools is hampered by the high cost of acquiring ICT devices, lack of reliable power supply, poor internet connectivity, lack of capacity building among the teachers, insecurity of ICT devices, and negative attitude among the teachers towards ICT integration. The government needs to establish leadership structures that enhance good governance in the procedure for inclusion of techno's in education. The survey by KNBS (2019) indicated that there is a substantial digital divide of 44% of the town population being able to access the internet, and the ratio is significantly lower at 17% in rural areas of Kenya. It is estimated that 60% of primary schools are covered by the Digital Literacy Program, but secondary schools are still below the UNESCO (2022) internal standards, and important to note that despite a significantly large number of tablets in primary schools, teachers in those schools are not making use of them.

It is a common occurrence to find the tablets kept in one of the storerooms of the schools for fear of losing them or a deficit of confidence in teachers in manipulation of the devices for instruction. The main purpose of integrating techno's devices in the instruction procedures is to equip learners with the market driven skills that help Kenya position itself as a hub for digital information, e-commerce, and the application of digital services. It is important to note that over five hundred (500) government services are available on the online platform called e-citizen, which enables every citizen to access any service they need at their convenience and place. The Kenyan government is also in the process of digitizing all the curriculum materials and different types of assessments in relation to the new Competency-Based Education and Competency-Based Assessment demands.

The incorporation of information technologies in education enhances access to excellence of education and makes the learning process enjoyable. The outbreak of COVID-19 in the year 2020 led to an increase in learning poverty, especially in the poorest countries like Kenya, such that 85% of the children were locked out of formal education, and the Ministry of Education did not have enough ICT tools to continue offering education online. Physics teachers are therefore challenged to apply the integration of information technology in their instruction procedures (MoE, 2020). This study sought to establish the determinants constraining the usage of information communication in the instruction process in Nairobi County, Kenya. The investigation embraced a descriptive research design, in which the research variables were described and summarized using descriptive and inferential statistics. Data was collected from physics teachers using the Physics Teacher Questionnaire (PTQ) and from physics students using the Physics Student Questionnaire (PST). Data from physics principals was collected using a structured Principal Interview Schedule (PIS). A sample of twenty-five (25) physics principals, thirty (30) physics teachers, and two hundred and fifty

(250) physics students were sampled using a stratified and simple random sampling procedures. The study involved thirty (30) public secondary schools randomly selected within Nairobi County and assumed to have been equipped with technological infrastructure. The collected data were processed using Statistical Package for Social Sciences (SPSS) software version 26.0, and the findings were presented inform of percentages, averages, and frequency tables. The analysis of qualitative information involved the transformation of unstructured data from the interview of the principals to form meaningful concepts through the process of categorization, coding and identification of the themes related to the problem of the study. Therefore, this chapter focused on the research methodology by discussing the research approach and design, population and sampling size, instrumentation of research tools, operational definition of variables and study procedures, and ethical assurances.

3.1 Research Approach and Design

3.1.1 Research Approach

The research approach refers to the systematic plans and procedures for conducting a scientific study with clear assumptions on how data will be collected and analysed with clear focus on the interpretation of the research findings (Cohen et al., 2002). The purpose of the study was to establish the constraints that limit the integration of the Information technologies in teaching physics and the use deductive model to discover the truth in making inferences to the entire population. The research was based on the education theories of education, which incorporated Social constructivism, Behaviourism, Cognitivism, and Connectivism that provided a firm foundation in supporting the concept of technology usage in physics instruction at the secondary education level. According to Creswell and Poth (2016), quantitative and qualitative research methods are very important to develop the learning theories, and therefore, in this study, they were critical for understanding how learners are effectively imparted with relevant knowledge and skills.

The invention of technology has greatly changed the instruction procedures and the infusion of technologies in the instruction process is based on philosophical worldviews. The introduction of technology in education has several advantages of making the learning process enjoyable through the provision of teaching resources that enhance understanding of abstract physics. The attitude of the physics teachers and students toward ICT integration is a key variable that was measured in this study to determine how it affects the process of utilisation of ICT facilities in physics instruction. The personal characteristics of the physics teacher, like age, gender, academic qualifications, teaching experience, and ICT knowledge, were very critical in understanding the limiting factors for teachers in using ICT in the classroom, and suggestions were made on what needs to be done for the teachers to start utilizing ICT resources effectively in the teaching profession.

Secondary physics teachers must understand the workability of ICT tools, for they know how to use them during lesson delivery. The lack of ICT skills among the teachers and students is one of the variables under investigation in this study. The study by Starkey (2020) highlighted that teachers lack ICT skills in how to operate machines; they tend to fear technology and would not be comfortable working with any ICT tool. The categorization of information by Bruner was dependent on the mind and the learning environment. The categorization involved coding, storing, retrieving, and transferring information from the teacher to the learners. The transferability of information from the physics teacher to the students is very important to enhance retention and make learning more interesting, even if the content is abstract.

It is important to allow the physics students to construct their knowledge to enhance understanding and retention. Constructivist theories of learning enhance metacognition aspects among learners and provide opportunities for learners to explain epistemologies of knowing (Starkey, 2020). Learners can interact with the environment and construct their own knowledge through experience. The glue that holds the learner's constructs of knowledge together is the meaning of what they have created, which acts as an interpretation of reality. The quantitative approach to this study was to examine to what extent are physics teachers and learners can create their knowledge in the classroom context using the available ICT resources. Are the physics students able to utilize the ICT resources in their respective schools to successfully achieve the learning outcomes? The customization of the physics content, like the simulation of concepts, creation of virtual labs, and classroom demonstration and experimentation by the physics teacher to meet the learner's needs, was very critical in achieving the learning goals. The quantification of the variables under consideration was instrumental for the researcher to make conclusions on how ICT is used in the process of physics instruction.

The connectivism theories of learning believe that knowledge exists in the world and not in the mind, as stated by their cognitivist counterparts. They argued that knowledge exists within the system or the working environment in which people live. The physics teachers and learners must participate in an activity that involves interaction in order for them to share new knowledge. Physics students learn through contact with each other by sharing knowledge and discovering what they have learned and observed from the environment through scientific practicals. The connectivism theory is directly linked to the current digital age and suits the current generation of learners. The current learning environment stipulates the use of technology to improve how learners live in schools, communicate, and interact with each other. It is the process of creating connections and developing a student-teacher network. The study examined the connectivism aspects of learning in schools that include effective communication through available technologies and social networking sites for learning. The computation on the use of social network sites was very critical for the study to establish how the students and teachers are effectively communicating with each other for collaboration purposes.

3.1.2 Mixed Method Research Approach

The study adopted a mixed-method research approach, such that both quantitative and qualitative data were collected simultaneously. The qualitative and quantitative data were analysed independently to identify the elements of convergence and divergence to solve the research problem. The two data sets of numerical and non-numerical were compared analytically to estimate the point of intersection and provide clarity on factors influencing ICT integration in physics instruction. The quantitative deduction process involved data collection from the sampled principals, physics teachers, and Form Three physics students relative to the prescribed propositions and research questions of the study (Newby, 2014). The qualitative data from the principals provided the researcher with rich and detailed information relating to ICT integration in schools from policy and administrative point of view, whereas quantitative data from the physics teachers and students explained the patterns and trends on the research problem. The study adopted a quantitative research approach to scientifically understand the determinant hindering the inclusion of technologies in physics instruction in Kenya. The variables were described, and inferential statistics were used through non-parametric tests to understand which factors are more prominent in hindering physics teachers not to using ICT in the teaching and learning process.

According to Creswell (2014), the quantitative approach is a postpositivist worldview in which the researcher is allowed to test a theory by stating the hypothesis and systematically collecting data to support or fail to support the stated hypothesis. The selection of the quantitative approach was based on the research problem of this study, such that the problem requires the researcher to systematically identify the determinants constraining the integration of Information and Communication Technology at the secondary level. Snyder (2019) explained that the quantitative approach is anchored on a deterministic philosophy that identifies the causes and effects of solving the research problem.

The researcher assumed that secondary schools sampled for the study have the necessary ICT infrastructure for teachers to integrate IT into the teaching process of their respective subjects. The worldview perspectives, designs, research problems, researchers' experiences, and the targeted audience for this study were the main factors for selecting the quantitative approach as a plan for conducting this study. This study calls for the identification of factors that cause the outcome and understanding of the best predictors of not using technology in the process of teaching physics at the secondary school level. The variables under inquiry included teaching methodology, capacity building, availability of ICT tools, and teachers' attitudes are well stipulated in the conceptual framework of the study that were critical to find out how they affect the teaching and learning of physics at the secondary school level. The clear identification of independent variables as well as a dependent variable under a large group of investigation that is randomly selected was the main reason why the mixed method approach was preferred as compared to only using a qualitative or quantitative approach. The qualitative data were very instrumental for triangulation purposes to ensure that the quantitative data from the physics teachers and students had either a convergence or a divergent point.

The quantitative approach requires careful observation of the variables under investigation to enhance the validity and reliability of the data collected, as explained by Creswell (2009). Since the researcher was more interested in describing factors hindering physics teachers in using ICT in the teaching and learning of physics, it was necessary for the researcher to use a mixed method approach so that the results of this study are generalized to the entire population. For instance, examining the study on teachers' attitudes about the usage of ICT by Hernández-Ramos et al. (2014) noted that on the factor validity and reliability of a quantitative study, the impact of both internal and external factors such as attitudes toward computers and the internet, self-confidence, and knowledge on the degree of information technology (IT) usage were very instrumental with a sample population of 1,898 Turkish pre-service teachers who took part in the study. The findings showed that Turkey, like many other developing nations worldwide, is still in the early stages of integrating technology into education. The majority of the pre-service instructors stated that they solely use simple ICT tools for pedagogical purposes. It was discovered that internal and external factors were connected to one another with the level of ICT usage.

The researcher's personal experience was also a key factor in selecting the quantitative approach as a method of scientific inquiry. The study of Doyle et al. (2009) on "*An overview of mixed methods research"* emphasized that the mixed method approach requires the investigator to collect and analyse both numeric and non-numeric data over a long period with more resources. The researcher has been trained in statistics and works in an environment of analysing numeric educational data to make sense of the figures for the audience to understand. The background training knowledge of the researcher was instrumental in selecting a mixed method approach as a positivist approach to establishing the truth about the factor limiting the usage of techno devices in physics instruction. In addition, the researcher is also more comfortable with a highly systematic method of collecting data and analysing the data using statistical procedures to make sense of the voluminous data. The quantitative approach was meant to test the hypothesis and determine the cause and effect of ICT in education and predict the best way to use the available technology in the teaching and learning of physics at the secondary school level. For instance, in the case of the qualitative approach, the data collected was non-numeric and required a non-statistical method of analysis, as noted by Truman (2023). The phenomenon under investigation was ICT integration in the teaching process, for which many researchers have opined that the use of ICT in the teaching process improves the quality of the learning process, but no study has been conducted to establish why teachers are reluctant to use ICT in the teaching process despite the government's efforts to encourage them to do so.

The collected data from this study were validated using reliable research instruments based on precise measurements. The deduction approach of the quantitative method was critical for generating a statistic that would be used to communicate to the entire population about specific variables of the study. It is important to note that positivism is associated with quantitative research and emphasizes absolute truth that needs to be established experimentally and through the study. The truth in this study would be based on the aspects of probability and variation of results with respect to the context, situation, and environment in which the participants would be located. The study by Leady and Ormrod (2001) and William (2011) explained that a quantitative study is helpful when data collected is analysed and presented in the form of facts, frequency tables, graphs, and charts for the audience to follow easily and be able to understand the research findings. The purpose of the quantitative research approach was to establish the truth so as to solve problems confronting the education sector in Kenya through systematic inquiry and collection of data for effective implementation of the research findings.

3.2 Research Design

The study adopted a descriptive convergent parallel research design. The rationale for using a descriptive convergent parallel research design in this study was to simultaneously collect both qualitative and quantitative data to compare the findings in making informed decision about ICT integration in secondary schools in Kenya. According to Tashakkori and Creswell (2007) and Creswell (2014), descriptive research "*is the procedure of collecting and systematically analysing data to effectively respond to the specific research questions or hypotheses*". Research design is the blueprint for data collection and measurement in terms of validity and reliability to analyse data for making conclusions. Gall et al. (1996) defined research design as the overall strategy for solving the research problem that requires the integration of different components of the study coherently and logically. The study explicitly examines determinants influencing the integration of Information and Communication

Technology at the secondary school level that would require a systematic flow of information and research steps to maximize efficiency and minimize expenditure and capitalize on the available time in order to discover the truth. The study focused on the use of ICT in physical education pedagogy, historical perspectives on ICT integration in education, identification of available ICT resources for physics teaching and learning, and examination of pedagogical methods. The scope of ICT integration in physics teaching in relation to the attitude of physics teachers affects the use of ICT, and it is very minimal in high school.

The descriptive research design has great potential to explain how the premise mentioned in the literature review would be described statistically for decision-making. Descriptive research design has a great effect on the concept of reliability of the research findings and provides a firm foundation for conducting future research (Johnson and Christensen, 2019). For instance, the study by Wachiuri (2015) on "*the effects of teachers' experience and training on the implementation of information communication technology in public secondary schools in Nyeri County, Kenya"* identified ICT implementation as the dependent variable, whereas teachers' training and experience in the classroom were the independent variables.

The study used the descriptive survey research design, and the sample used consisted of 275 teachers who have been employed in 15 secondary schools in the Nyeri Central district that are state schools. The sampling strategy was stratified random sampling, and 82 teachers were taken as the sample. Moreover, 15 principals of the schools in the Nyeri county were also chosen to be included in the study. Research instruments applied in data collection included a questionnaire, an interview schedule, and an observation schedule, and data were analysed in a quantitative manner. The study established that most schools, specifically those in rural environments, have been pushed to embrace ICT. To a great extent, this became possible due to insufficient training of the teachers, insufficient knowledge, and a negative mindset towards the adoption of ICT.

When deciding on the suitable research design, the study emphasized efficiency so that the validity and reliability of the tools employed in the collection of data are enhanced, and the correct data collected. The descriptive research design would also help in finding the flaws and shortcomings of the structure of ideas to be examined critically. Kothari (2004) noted that the research design must have credible data since this will reduce the researcher's bias and optimize the accuracy of the data collection and analysis. This research thesis is associated with the descriptive research design because it was reported to determine the factors that hinder the application of ICT in teaching and learning physics in high school. The research design provided deep research into the patterns, attitudes, and opinions of physics teachers and physics students on the issue of ICT integration in the teaching and learning of physics. Vockell (2021) further notes that the analysis of data suggests the application of inferential statistics would yield more detailed data to make an inference about the whole population based on the specific sample. The descriptive cross-section research design was economical to allow the researcher to gather the relevant data, conduct data analysis, and make conclusions about the research within the designated time and location.

The descriptive statistics employed in the research design were able to identify the variables affecting the process of ICT integration in the teaching process and generate attributes for decision-making. The researcher was more interested in describing the variables and examining the current situation in Kenyan schools by identifying attributes related to ICT integration in education. For the researcher to be able to support or fail to support the research hypotheses of this study, the data collected needs to be quantified and inform numerical data by subjecting it to statistical treatment in order to make valid conclusions. The descriptive research design provided an opportunity for the researcher to deeply understand the process of

ICT integration in Kenyan schools and identify what needs to be done in order to effectively utilize the ICT facilities, especially in secondary schools, to improve the quality of education. The advantage of using a quantitative research approach is that it involves a descriptive research design that produces objective data inform of numbers that communicate the current situation of the research problem and enable the study to be replicated by other researchers. The aspects of speed and efficiency are very critical when using the quantitative approach in solving a research problem. The correlation between the independent variable and dependent variables was described in terms of numerical variables for prediction and decision-making purposes.

3.3 Population and Sample of the Research Study

3.3.1 Area of the Study

The research was conducted in Nairobi County in Kenya. Based on the market research conducted by KNBS (2019), Nairobi is the Kenyan capital and the largest business hub, which has a population of about 4 million people in 17 sub-counties and 85 electoral wards. Machakos is on the eastern border of Nairobi and Kiambu County, and Kajiado to the north, respectively. It possesses a fairly developed infrastructure and industrialized foundation, contributing to approximately 20 percent of the gross domestic product of the nation, and the schools are presumed to be furnished with ICT infrastructures. Similarly, other educational authorities include the Teachers Service Commission (TSC), the Kenya Institute of Curriculum Development (KICD), and the Kenya National Examinations Council (KNEC) are found in Nairobi city.

Nairobi covers a total area of 696.1 km² with 610 mm of rainfall in two rainy seasons in the city. The Nairobi poverty rate is low and stands at 21.8 percent compared to the poverty index of the country, which stands at 45.9 percent. The assumption is that most of the secondary schools in the Nairobi County have the ICT infrastructure to both teach and learn, and that is why the study aims to establish why the physics teachers are not utilizing the available ICT tools in the teaching process.

3.3.2 Targeted Population

According to Adami and Kiger (2005), when they were examining "*The use of triangulation for completeness purposes,"* the term population refers to the aggregate or totality of all elements having the same characteristics. The population of this study consisted of 120 principals, 276 physics teachers, and 3200 Form three physics students, totalling 3596 participants within Nairobi County, Kenya. Of importance to note is that this population involves the key stakeholders for the implementation of physics curriculum at secondary school level. The school principals are critical in policy and administrative guidance for the smooth operations of the schools in Kenya. The principals are able to advise resource allocation, ICT integration policies in schools as well as effective implementation of the curriculum in their respective schools. The physics teachers of which are a substantial proportion form head of science department are the classroom curriculum implementers; hence their experiences, competencies and attitudes are crucial for effective usage of ICT in the school. The Form three physics students are at the stage at which they have requisite skills about curriculum implementation and methodologies used by their respective physics teachers for effective instruction. The study was carried out in government-funded public secondary schools with the assumption of having provided with ICT infrastructure.

The government had ordered the delivery of the computers and other ICT-related equipment to the county secondary schools, which had 76 physics teachers and 753 Form Three physics learners, to serve the purpose of education, as indicated by the report by the Nairobi County Education Office. This gave 921 individuals as the target group in the study. This study aimed at revealing how the incorporation of ICT in the instruction of physics is compromised in schools in Nairobi County. The purpose for inclusion of the principals in this study was to get insights about the policy formulation and implementation on the school level, and the availability of resources and infrastructure that directly influence the ICT implementation in the targeted school. The main issues physics teachers encounter with utilizing ICT resources to teach include training, confidence, attitudes, and working with the curriculum. The students in Form Three were in the upper secondary level of education, and as such, they were provided with informed feedback on how ICT was implemented in their physics classes and their level of participation, and the importance they attached to it concerning their level of understanding.

The sample consists of 76 principals and 92 physics teachers from a considerable percentage of the secondary schools of Nairobi County, which gave the study a wide scope of the sample of the institution and generalizes the results of the study. The 753-student sample was proportionate to yield statistically significant information by the use of surveys or focus groups, which enhanced the validity of the obtained information. The issue of the study was timely because the students in Form Three are normally exposed to more difficult content in the subject Physics, and they have enough time for exposure to activities in the classroom. In the near future, they will take the KCSE, and thus their answers were timely and of utmost importance. This sample provided the opportunities of carrying out quantitative statistical analysis, the triangulation of data of the three groups, and the comparison of teacher and student perception of schools with ICT infrastructure in place with the schools that do not have it.

The study involved participants who were in school at the time of data collection, and special schools having special needs students were excluded, but special physics students who had been integrated into the mainstream were allowed to participate. Despite the government's efforts to provide technology resources, school principals, physics teachers, and students from the study's target population greatly contributed to the study's determination of determinants influencing the integration of ICT in the process of learning physics.

3.3.3 The Eligibility Criteria of Sampling

The targeted people had predefined characteristics that aided in providing relevant information to the study. The target population included participants from Nairobi County's public secondary school environment, including principals, physics teachers, and students. The study included both male and female participants ranging from 17 to 60 years in age. This study did not take into consideration participants' social characteristics such as race, religion, tribe, or ethnicity. The principals of the sampled schools participated in this study because they execute and implement government policies on ICT integration in schools. The principals are accountable to the Ministry of Education for the prudent use of resources and the academic performance of the students; therefore, they play a critical role in school administration and supervision of ICT and human resources. The study involved the use of ICT in teaching and learning physics subjects, and therefore, the physics teachers are instrumental in identifying factors that might be limiting their use of ICT-related resources. The majority of physics teachers use computers for keeping assessment records and searching for information from the internet due to the strong correlation between the use of ICT tools and the content of physics.

According to Hassan and Mondal (2021), it was noted that it is easier for physics teachers to understand the operation of ICT resources because most of the ICT devices operate on physics principles, as compared to the other subject teachers, and that is why the study sought to identify the limiting variables for physics teachers who did not use ICT in the classroom. Physics students also play an important role in this study by providing insightful information on why they believe their teachers should use ICT during the teaching and learning process. The study selected form three physics students because they have covered an adequate portion of the physics curriculum and can make informed decisions on the importance of using ICT in the learning process. Students also live in the twenty-first century, which is marked by a technological revolution informed by computers, mobile phones, and the internet, and they will be more comfortable if teachers can teach them using the available technologies to make the physics lesson more interesting and exciting for them.

3.3.4 Sampling Techniques and Sample Size

Sampling is the process of identifying the desired subset of the population to participate in the study. It is simply the process of selecting a sample from the targeted population. According to Creswell (2018), sampling is very important in educational research because it helps researchers to infer information from the sample to the entire population and determines the accuracy of the research findings. According to Mugenda and Mugenda (2013), 30 percent of the targeted population is a representative of the population and suitable for quantitative research. In a mixed method paradigm, the sampling of quantitative data should be adequate enough to achieve the rigour and statistical power while for the qualitative data the sample should achieve the situation power (John & Vicki 2018). Therefore, samples of 30 percent of the target population were approximated in this study to constitute a sample of each group of participants, as shown in Table 4. The research publication by Creswell (2018) has indicated that in a simple random sampling, all the members of the targeted population have an equal opportunity of being selected as a sample size of a study.

The research entailed a stratified and simple random sampling procedure due to the fact that the subgroups were not homogeneous and included principals, physics teachers, and students who were selected. Walliman (2021) defines stratified sampling as one of the sampling techniques, which will help to increase the accuracy and representativeness of a sample in cases where the population is heterogeneous, and a sub-population possesses specific features. It makes sure all the subgroups are adequately represented; therefore, the achievement of more correct and reliable results is achieved. Most especially, this proves to be of use when subgroups have a relatively homogeneous collection of attributes, e.g., age or geographical location. The stratified sampling could also be used to represent of the subgroups, i.e., dominant groups are not overrepresented, and minority groups are not underrepresented. This minimized bias, as they were given proportional representation, and not having some groups being ignored or overrepresented. This assisted in preventing such biases in research, such as an under-age bias.

The stratified sampling was also used to allow studying the different subgroups separately, gathering information about each group, and therefore provide the researcher with the chance to compare and contrast the characteristics of the different strata (Walliman, 2021). This gives information on the variation of the variables or outcome of the selected variables between the different subpopulations of the population. The stratified sampling increased the accuracy since simple random sampling of a small sample size is less complex and cheaper. This was specifically true since the subgroups were more homogenous than the population.

Simple random sampling is a research technique that is used to constitute an accurate sample of the larger population in which every member has an equal chance of being selected. The approach is less biased and enhances the generalizability and enables statistical analysis (Creswell, 2017). It reduces the chances of bias, permits much confidence about utilizing inferences of the big population, and is a requirement of most statistical operations. It is also viable and cost-effective, as it is easier to implement and may be less expensive as compared to other processes. The confounding variables will be manipulated by randomization, thus increasing the accuracy of the findings of the study. The discussed study produced a big sample; therefore, simple random sampling was just suitable in reflecting the features of the vast population to ensure that the findings will be generalized to the vast population.

A simple random sampling method was used to select 25 public secondary schools from 76 schools within Nairobi County, and therefore, the principals of the selected schools were purposively selected to participate in the study. To ensure the representativeness of the sample, a simple random method was also used to select 30 physics teachers and 250 Form three physics students to participate in the study, as shown in Table 4. Therefore, the study involved sampling of 305 participants which represented 33% of the entire population of 921 as shown in Table 4. The 25 principals were purposively sampled by the virtue of their schools being sampled and therefore they were key informants in providing rich information related to administration and management of their respective schools as far as ICT integration is concerned. The sampling of thirty and two hundred and fifty physics teachers and students through simple random sampling ensured that each member had equal chance of selected to avoid bias and ensure representativeness of the population. The use of purposive and simple random sampling in this study was to achieve the rigour and objectivity of the findings as clearly explained by ATLAS (2024) on strategies for sampling. The sampling frame is tabulated as shown in Table 4.

Table 4

Sampling Frame of Participants

S/No	Category	Total Population	Target Population	Sample Selected	% Sample Selected	Sampling Method
1	Principals	120	76	25	33	Purposive
2	Physics Teachers	276	92	30	33	Simple Random
3	Physics Students	3,200	753	250	33	Simple Random
	Total	**3,596**	**921**	**305**	33	

The data of the targeted public secondary schools was obtained from the Nairobi County Education Office. The gatekeepers and research permit obtained from the National Commission for Science, Technology and Innovation (NACOSTI) within Kenya were used to access information from the selected public secondary schools. The school principals provided the researcher with school registers for both the teachers and students for the researcher to sample the required sample size for the study. A computerized random table was used to select the required sample size, as shown in the sampling frame in Table 4, to ensure that each participant had an equal chance of participating in the study. The sample size had a great significant impact on the quality of the research findings in terms of reliability and validity of the data collected.

3.4 Instrumentation of Research Tools

3.4.1 Introduction

This section was informed by the research aims and objectives and clearly elaborated on the research tools that were used in the study to collect primary data and the development of the research tools. The research formulated three data gathering tools, and they were the Principal Interview Schedule (PIS), Physics Teachers Questionnaire (PTQ), and Physics Students Questionnaire (PSQ). The data was gathered by the use of questionnaires and structured interview schedules.

3.4.2 Data Collection using a Questionnaire

A questionnaire is a list of items used to collect information from the respondents about their feelings, attitudes, opinions, or life experiences with a specific objective focused on responding to a research problem (Creswell, 2017). The researcher adopted a structured questionnaire for collecting quantitative data from the physics teachers and students within Nairobi County, Kenya to address the research problem on factors influencing the use of technology in physics instruction. The questionnaires consisted of a set of closed-ended and open-ended questions that allowed respondents to select objective responses and elaborate on some questions by giving more information related to the study.

The data collected by the questionnaires were in a standardized format, enhancing the internal validity of the tool and easier to analyse (Creswell, 2017). The researcher opined to use questionnaires for data collection because the development and administration of the tool was a bit inexpensive, enhances the privacy and confidentiality of the respondents, and it was easier to corroborate the research findings with other data collection tools like the interview schedules that were used in this study. The study adopted the use of questionnaires for data collection due to the large sample size involved and the objectivity aspect of gathering valid data.

Triangulation of the collected data from questionnaires was used to enhance objectivity and validity with other responses from the interview schedule. The Physics teachers' and students' questionnaires had multiple scales of five-point Likert scale items that were customized to address a specific research objective. For clarity and efficiency in gathering responses from the respondents, a single set of anchors was presented for each multiple rating scale for the teachers' and students' responses. The following data collection tools were developed and used for this study.

3.5.2.1 Physics Teachers Questionnaire (PTQ)

The questionnaire was developed to collect information from secondary physics teachers relating to the determinants constraining the integration of Information and Communication Technology. The items in the physics teacher's questionnaire were customized from an existing bank of items from other peer-reviewed studies having similar constructs and addressing the same research problem. The questionnaire had two sections, A and B, such that section A captured the biodata of participants and section B captured information relating to the determinants constraining the integration of Information and Communication Technology. The questionnaire had simple items that required a yes or no response to more complex items testing the knowledge of ICT integration in education using Likert scales. For the Likert scale statements, the participants were provided with responses ranging from Strongly Agree (SA) to Strongly Disagree (SD) with measurement values ranging from 1 to 5, respectively. The questionnaire also contained a few items in which the respondents were encouraged to elaborate on answers that they had provided in the previous stem questions in relation to the new linked item. The validity of the questionnaire was validated by experts from UNICAF University and local universities in Kenya to ascertain their suitability in the objectivity of measuring the required research objectives.

3.5.2.2 Physics Students Questionnaire (PSQ)

The questionnaire was used to collect information from the Form Three physics students about the determinants influencing the integration of Information and Communication Technology in physics instruction. The Physics Students Questionnaire (PSQ) was tailored to the level of the students for them to be able to understand the questions correctly and provide valid and honest responses. The physics students were guided by their teachers in signing the consent form in order for them to voluntarily participate in the study or even withdraw from the exercise if they wished to do so. They were also briefed by the researcher that they were not sitting for an examination but responding to a questionnaire to improve the use of ICT in the instructional process. The student's questionnaire also had two sections, A and B, in which section A captured the biodata of the physics students and section B captured information relating to the use of ICT in physics instruction. The students were briefed about the significance of the study and the ethical consideration factors, such that they were assured of confidentiality and privacy of the information they provided for the study.

3.5.2.3 Data Collection by Interview Schedule

In-depth interviewing is a qualitative research method that involves using a small number of respondents to conduct its extreme individual in-depth interviews on a specific topic, program, or issue (Creswell, 2017). Interview schedules are significant when you require certain information on the opinions and habits of a person or when you wish to delve deeper into a new subject. They are used to contextualize other data, providing a more in-depth view of what transpired in the program and why (Creswell and Poth, 2018). They give far more extensive information than other data gathering techniques, such as surveys and questionnaires. Because of the time it takes to conduct interviews, transcribe them, and evaluate the findings, they may be time-consuming assessment activities, which is why only the principals responded to the interview schedule in this investigation. The procedure of conducting in-depth interviews with school principals for this study included planning, designing the instrument, collecting data, evaluating data, and disseminating the investigation findings. According to Creswell and Poth (2018), conducting interviews allows the researcher to effectively understand the participants perspectives in their own text and wording and explicitly explore the research problem to find amicable solution. The usage of a structured interview schedule saved time for both parties involved since the questions probed by the interviewer were logically synced to have leading replies from the interviewee. The next section discusses the interview schedule for the secondary school principals who were used in this study.

3.5.2.4 Principal Interview Schedule (PIS)

According to Coley (2018), an interview schedule is a list of structured questions that the interviewer systematically asks for responses from the interviewee. The interviewer had the option of rearranging the questions based on the principal's teaching experience, feelings, demographic factors, and perception of the school. The study adopted a Principal Interview Schedule (PIS) that was significant for the school principals to provide insightful information about the process of ICT integration in education within their respective schools of jurisdiction. The principals play a critical role in implementing government policies on ICT integration at the school level, and therefore, they have the pertinent information on how ICT is being integrated in their respective schools. The structure of this interview schedule was based on Coley's (2018) guidelines, who indicated that an interview schedule should consist of leading and probing questions that elicited responses that were captured by writing and recording for specific principals who consented to be recorded.

The interview schedule had a wide range of questions that logically followed each other from simple to complex, requiring principals to elaborate on some concepts, limiting the use of ICT in the teaching and learning process in their respective schools. The resultant data on the principals was also supplemented with the data on the physics teachers and students in order to come up with emerging themes on the findings of the research by using the triangulation approach. The interview schedule was well organized, bearing in mind that the principals have a tight schedule, and thus it will take approximately 30 minutes based on the information given by the principals on the ICT integration in education. The next section examines about the piloting of the instruments used in the research study.

3.4.3 Piloting of the Research Tools

Piloting is the process of pre-testing of research instruments that validate them and make them reliable, as explained by Crewell (2017). Data quality improvement involves identifying whether the proposed research could be done, collecting preliminary data, testing validity and reliability, refining research questions, training the researchers, identifying ethical issues, and inculcating confidence in the results output were the essential functions of piloting the research tools. Further, piloting also provided an opportunity to test methods, tools, and procedures on a smaller scale and then replicate them on a larger scale. In addition, piloting of research instruments was also useful in identifying the potential research problems and making the required corrections that led to the improvement of validity and reliability of the main study.

Pilot testing allowed the researcher to identify study design problems, data collection options, measurement tools, wastage of time and resources utilisation for the study. It also made sure that information was valid and correct, determined the feasibility and viability of the study, and increased efficiency. It also contained the pilot information that indicated the main study design that was readjusted, and an atmosphere was created for the size that was to be implemented as a sample size. The pilot testing was quite essential because it gave the empirical concept of the procedures and instruments, revealed the possible ethical issues, and established confidence in the possibility of the successful accomplishment of the main research as discussed by Creswell (2017). Piloting of the research tools was done by administering the research tools to a selected sample with a homogenous nature to the main study, with a clear goal of enhancing the reliability and validity of the research tool. The instrument testing was done in one of the secondary schools in the study area, but the school did not participate in the massive research. The characteristics of the school selected to be piloted were similar to those of the rest of the schools in the sampled population. To start with, they were given the right to travel with NACOSTI and the Ministry of Education in Kenya through liaison with the school principals, with the approval of UREC from UNICAF university.

The tools were administered twice within an interval of seven days to the school principals, physics teachers and students. The participants were allowed to respond to the items after signing the consent form, through writing, while the information from the interview schedule was captured by the researcher. The data collected by the tools were cleaned and entered into the SPSS software for analysis through the correlational techniques. The response on each item of the research tool was correlated to establish the correlation coefficient by bivariate correlation in SPSS. The reliability coefficient for PTQ and PSQ was found to be 0.82 and 0.79, which were deemed to be acceptable for the collection of data during the main study according to Creswell (2017). According to Taber (2018), a statistically accepted rule for the reliability coefficient is 0.6 to 0.7 or a greater value. The reliability for PTQ and PSQ was above 0.6, indicating the suitability of the research instruments.

The items in the research tools were critically analysed to improve their accuracy and objectivity in capturing accurate information relating to the study. The face and content validity of the research tools were also improved by making some questions clearer and more precise for responding with respect to the research objectives. The guidance from the supervisor helped the researcher to significantly modify the research tools such that they were able to measure what they were intended to measure in the study. The piloting process of the research tools involved deletion of the ambiguous questions and restructuring some questions of the tools to generate valid and credible data for analysis.

3.5 Study Procedures and Ethical Assurances in the Study

3.5.1 Introduction

The ethical considerations of the participants were given the major priority to ensure their well-being of the participants. According to National Committee for Research Ethics in the Social Sciences and the Humanities (2022), ethical assurances involve informed consent, which is critical to safeguard the rights and welfare of participants by ensuring that they comprehend the nature, potential benefits, and potential risks of the study and can make an autonomous and informed decision about whether to participate or not. Ethical consideration is significant in the study to ensure that the data collected is reliable and valid. The principles for ethical consideration for this study included voluntary participation, signing of informed consent, anonymity, and confidentiality of participants' information. The researcher ensured voluntary participation by clearly communicating the purpose of the study, the procedures that were involved in the data collection, and how beneficial the study was to the participants. The physics teachers and students were not coerced to participate in the study and had the right to withdraw freely from the study without any penalty. The researcher sought consent from the participants to ensure that the participants freely agreed that their information to be used solely for the study. The researcher maintained the anonymity of the participants' details by ensuring that personally identifiable information was not collected and the research tools were coded for easy analysis.

In addition, the tools for data collection were submitted to the UREC Committee, and the decision to use them was approved, allowing the researcher to administer the research instruments. The data collection tool had an introduction section to explain the importance of the study to the participants and an informed consent section for the participants to agree or disagree with when participating in the study. The informed consent allowed participants to freely understand their right to leave the study at any time, without having to justify their decision and without facing any consequences. The data collected from the respondents remained confidential, and the research tools remained anonymous, such that details relating to the identity of the participants were not written on the research tools. The data collected for analysis remained under lock and key and was strictly accessed by the researcher for analysis. The researcher's responsibility was to protect the participant's dignity and use effective communication to state the purpose of the study, which is aimed at finding the determinants influencing the integration of Information and Communication Technology in the instruction process. The approval to conduct the study and collect data from the sampled participants was received from the UNICAF Research Committee (UREC) on **2nd May 2023** after the submission of the necessary documentation and research tools.

The gatekeepers were signed by the supervisor and the researcher as a necessary document for approval with Kenyan research institutions and subsequent collection of data. The approval by UREC was the first step in ensuring ethical considerations among the participants involved in this study. The researcher then requested the Unicaf academic registrar to offer an official introductory letter for identification in the Kenyan institution as a doctoral student collecting data for academic purposes only. The receipt of the official letter from Unicaf enabled the researcher to apply for the research permit license from NACOSTI, which is a

Kenyan constitutional body mandated with issuing research permits to potential researchers in Kenya. The researcher made an application for the research license through the NACOSTI online portal, and after three weeks, a license was issued with a specified duration period of one year. The researcher briefed the participants on the significance of the study and targeted respondents with the requisite introductory ethical approval documents to be allowed by the school principals to collect data. The physics students were adequately guided by their guardians or teachers on the significance of the study and how to sign the consent form. The researcher explained to the participants the importance of the study, and the following section discusses the steps taken during the data collection exercise.

3.5.2 Steps Taken in Data Collection

The data collection process involved various steps that included the identification of schools, the scheduling of activities, and the actual data collection process. The collection process was done with adherence to the research objectives and aimed at establishing the constraints limiting the integration of ICT in physics instruction in secondary schools in Kenya. The data collection process involved collecting data from the school principals, physics teachers, and students who were sampled for the study. The following steps were observed during the data collection.

3.5.2.1 Identification of schools for data collection

The researcher collected data from the twenty-five (25) sampled secondary schools within Nairobi County in the Republic of Kenya. The data was collected from 25 principals, 30 Physics teachers, and 250 physics students as identified from the sampling frame. The planning of the data collection process involved assigning dates to each specific school and organizing transport logistics and other subsidies for an effective data collection process. Further, the researcher was equipped with the data collection tools that were both in hard copy and soft copy for the data collection exercise. The time frame for data collection was set from 12^{th} June 2023 to 30^{th} June 2023, when the students were in session.

3.5.2.2 Determination of Data Collected

The researcher had to notify the sampled schools of the nature of the specific data to be collected during the tools administration process. The dates for data collection were communicated to the schools before the commencement of the data collection exercise. The methods of filling out the interview schedule and questionnaire were discussed with strict adherence to the participant's ethical consideration of free withdrawal from the study and signing of the consent form. The filling method involved using a tick (√) to select the response from various responses provided on each item in the questionnaires or writing short sentences as responses. The gatekeepers were used to introduce the researcher to the respective schools and create a rapport with the respondents for an effective data collection process.

3.5.2.3 Data Collection Methods

The participants were informed of the significance of the research and the ethical guarantees that the researcher undertakes in data collection by the researcher. The research entailed gathering both quantitative and qualitative data that were triangulated at the analysis stage in accordance with the research objectives. The triangulation approach estimated the transformative convergence in the data analysis as it responded to the research objectives. Therefore, quantitative data were collected using the physics teachers' and students' questionnaires and coded for analysis, while qualitative data collected from the principal's interview were coded, transcribed, and discussed as emerging themes in the discussion section. The researcher provided Principal Interview Schedules (PIS), Physics teachers, and students' questionnaires to schools that are equivalent to their sampling size.

The researcher ascertained that the data collection tools were printed correctly, and all items were included in each tool for effective data collection. The administration of the data collection tool was face-to-face, with cases of mobile interviews with school principals who were busy with other responsibilities of the school the region sampled. The researchers had to reschedule a convenient time for data collection depending on the availability of the participants. This ensured the accuracy of a hundred percent response rates on all the tools used in the study. The researcher was guided on the process of conducting an effective interview with the school principals by booking appointments and signing the consent form.

The researcher strictly adhered to the guide provided and only inquired from the principals on the questions provided in the interview schedule and allowed the principals to elaborate on some of the points explained for a better understanding of the research problem. The researcher guided the physics teachers and students on how to fill questionnaire and explained to the physics students that they are not doing an examination but just filling out a questionnaire to improve the quality of physics instruction using ICT. The researcher captured more information relating to the study as much information as possible from the participants due to various dynamics of the secondary schools in Kenya, because some schools are well equipped with ICT infrastructure, while others are not. The school principal was to act as a link between the researcher and the physics teachers and students for quantitative data collection using the PTQ and PSQ tools. The PTQ and PSQ were filled by the teachers and students at their convenient time after signing the consent form without interrupting the regular programs of the school. The duly filled questionnaires and interview schedules were returned to the researcher after the time set for data collection had elapsed. It is important to note that even the data collection tools that were not filled were also returned to the researcher for safe storage and custody.

3.5.2.4 Data Collection

It was important to ensure that the data collection method was free from any challenges, especially from the site of the researcher to enhance the objectivity of the study. The data collection was clear, legally acceptable, and ethical, with strict adherence to participant confidentiality and privacy of their information. The data collection process forms an integral part of this study in answering the research questions and hypotheses. The data collection procedure involved the use of questionnaires and interviews for the collection of both quantitative and qualitative data from the principals, physics teachers and students. The collection of both quantitative and qualitative data was done to validate the data from the physics students, teachers, and the school principals. This involved the identification of discrepancies, convergence points, and the uncovering of new information related to determinants influencing the integration of Information and Communication Technology. The qualitative data from the school principals was insightful in uncovering new insights on the government policies related to ICT integration in secondary schools with respect to actual implementation by teachers. The triangulation involved using different data sources, methodologies, and learning theories to explicitly address the research problem. The collected primary data was kept under lock and key by the researcher for comprehensive analysis.

3.6 Operational Definition of Variables

3.6.1 Introduction

The main purpose of this study was to establish determinants influencing the use of Information and Communication Technology (ICT) in Physics instruction at the secondary school level in Nairobi County, Kenya. The study adopted a descriptive research design in which variables of the study were described and summarized using measures of central tendency and inferential statistics. According to Graham and Harris (2016), operationalizing a variable or concept means defining it so that it can be measured and or expressed quantitatively or qualitatively. The study by Andrade (2021) on the topic "*A Student's Guide to the Classification and Operationalization of Variables in the Conceptualization and Design of a Clinical Study: Part 2"* affirmed that the process of operationalization of variables in any study should start by unpacking the research objectives through identifying the key actions to be undertaken and dividing the variables into dimensions and indicators. The major reason for the operationalization of variables in this study was to ensure the audience explicitly understands the research objectives and remove potential ambiguities. The following were the primary constructs associated with each research question (RQ) or hypothesis stated;

RQ: 1) What ICT resources are available for use at the secondary school level for the Physics instruction in Nairobi County, Kenya? For this research question, the dependent variable (**DV**) was the Physics instruction in secondary schools, while the independent variable (**IV**) was the availability and utilisation of ICT resources like desktop computers, laptops, projectors, printers, and reliable internet connectivity. In the data collection tool, the respondents have identified the available ICT tools in their respective schools that can be utilized for effective physics instruction. The measurement level of the independent variable (IV) was nominal and required participants to select Yes or No on the availability of each ICT tool, and they were given space on the questionnaire to suggest more ICT tools that are available in their respective learning institutions. The statistical analysis of this research question involved the use of descriptive statistics, like frequency tables and modes, to determine which ICT tool was frequently available in schools. The researcher used SPSS software version 26.0 to process the frequency summary reports, including means and standard deviation, for the available ICT tools in the sampled secondary schools within Nairobi County.

RQ: 2) What ICT-integrated strategies do the physics teachers use for teaching Physics at the secondary school level. The dependent variable (**DV**) for the research question was teaching Physics at the secondary school level, while the Independent Variable (**IV)** is ICT-integrated strategies. The respondents identified ICT strategies available for teaching and learning physics from the data collection tool, and they identified the ICT strategies for teaching physics that were instrumental in improving the quality of teaching and learning. The

ICT strategies involve methods like computer simulations, animations, PowerPoint presentations, virtual discussions, demonstrations, and experimentation with physics concepts. The independent variable was measured on a nominal scale of indicators, *Yes* or *No*, which are coded 1 or 0 for descriptive analysis. A non-parametric test (Mann-Whitney U) was used to determine the acceptance level or fail to accept the null hypothesis at the significance level of 0.05.

RQ: 3) How does the physics teacher`s attitude affect the use of ICT in physics instruction? The independent variable (**IV**) is the attitude of the physics teachers, and the dependent variable (**DV**) is the use of ICT in physics instruction. The respondents were given a set of statements about their beliefs, thoughts, and feelings on the use of ICT in physics instruction, and they were supposed to respond to each statement by the use of Likert scale ranging from Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD). Each indicator of the statement was coded 1= Strongly Agree (SA), 2 = Agree (A), 3 = Neutral (N), 4 = Disagree (D), and 5 = Strongly Disagree (SD) for descriptive analysis.

RQ: 4) How do physics students affect the use of ICT in physics instruction? For this research question and null hypothesis, the independent variable (**IV**) is the attitude of the physics students, and the dependent variable (**DV**) is the use of ICT in physics instruction. To accurately measure the response variable the physics students were provided with statements relating to their beliefs, thoughts and feelings on the use of ICT in physics instruction and they were supposed to respond to each statement by using of Likert scale levels of agreement or disagreement from Strongly Agree (**SA**), Agree (**A**), Neutral (**N**), Disagree (**D**) and Strongly Disagree (**SD**). Each indicator of the statement was coded 1= Strongly Agree (**SA**), 2 = Agree (**A**), 3 = Neutral (**N**), 4 = Disagree (**D**), and 5 = Strongly Disagree (**SD**) for descriptive analysis. The descriptive statistics involved analysis of variables using the median and mode and generating a frequency table.

3.6.2 Variables of the study

Variables are measurable characteristics that cause a change in another quantity. They are simply attributes and concepts through which a logical measurement of a property is determined (Creswell, 2018). The variables for this study were defined in the context of a population that included the school principals, physics teachers, and students. This study consisted of the dependent variable, intervening variables, and independent variables in determining determinants constraining the use of ICT in physics instruction at the secondary school level in Kenya. From the conceptual framework of the literature review, the dependent variable was the use of ICT in Physics instruction, while the independent variables included the availability of ICT resources in schools, ICT-integrated strategies for teaching, attitudes of the physics teachers, and students. The intervening variables for this study included the school and home characteristics, duration of lesson presentation, and class size. According to Arias (2012), intervening variables in a study are not measured or operationalized. The study assumed that all the physics students had been exposed to the same learning environment both at home and at the school level.

According to the Ministry of Education (2017) guidelines, the study assumed that a single physics lesson should last for 45 minutes as stipulated in the Education Act, Cap 211, and this duration is what the physics teacher needs to impart knowledge to the students across the sampled classes. According to the Kenyan Constitution 2010, Education Act Cap 211, the law requires that there shall be a maximum of 50 pupils per class in Primary school and a maximum of 40 students per class in secondary school, and a maximum of 30 students per class in teachers' college or intermediate college. It was further assumed that the physics teachers had been retooled on the use of ICT in physics instruction, and the sampled schools had been equipped with the necessary ICT infrastructure.

Through operationalization of the study variables, the research objectives were converted into research questions and hypotheses for easy analysis of the quantitative data and discussion of the qualitative data as emerging themes in the study. Operational definitions were steps taken by the researcher to measure the variables under investigation. Operationalization of the study variables involved the process of converting immeasurable ideas into quantifiable observations, from which the researcher was able to gather sufficient data from the hypothesis to develop educational theories or guidelines for effective utilisation of ICT resources at the secondary school level in Kenya. The definition of operations provides the reader with the obvious, precise, and communicable meaning of research concepts used to measure the new knowledge achieved in the study. Operational variables for this study were defined within a set of fixed boundaries of the study objectives. It was important to define every term included in the operationalization of variables to ensure that all the key constructs are well stated during the data collection and analysis.

According to Arias (2020), a variable is a verb or a phrase in the research topic or objective that is measurable using an appropriate measuring scale. The constructs of this study were created by converting the constructs into measurable forms. The major aim of the operational definition of variables was to identify how the variables in this study are calculated in numeric form and later measured. The definitions of variables specify the possible values of variables and the levels of measurement of each variable. To absolutely measure a variable, at least two dimensions for each variable in the four research objectives were formed, and each dimension had at least two indicators. The dimensions were the factors obtained from the variables and could easily be measured and broken down into indicators. The dimensions for this study were based on the variables stated and the conceptual framework.

3.6.3 Indicators of the Variables

According to Baena (2017), indicators are the concrete elements of the dimensions, and they are the measurable reality of the variables. The indicators of the variables in this study are the evidence that a variable to be measured exists in the objective. Indicators are expressed in words or phrases and sometimes numbers. For instance, in this study, a variable like gender had the following indicators like male, female, and prefer not to mention, while objective statements having a Likert scale were measured using indicators Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5). The measurement scale of 1 to 5 was assigned arbitrarily and ensured that variables were measured on an ordinal scale. A variable like age was in the biodata of the participant's questionnaire and required them to select their appropriate age bracket from the indicators of Less than 22 years coded as 1, 22 - 29 years coded as 2, 30 - 39 years coded as 3, 40 – 59 years coded 4 and 60 years and above coded as 5 for easy analysis in the SPSS software.

Table 5 shows the operationalization of the research variables as guided by the research objectives.

Research Objective 1: To assess the availability of ICT resources in secondary schools for Physics instruction in Nairobi County.

Research Objective 2: To assess the ICT-integrated strategies for teaching Physics at the Secondary school level.

Research Objective 3: To establish how the attitude of physics teachers affects the use of ICT in physics instruction.

Research Objective 4: To establish how the attitude of physics students affects the use of ICT in physics instruction.

Table 5

Variables operationalization

Objectives	Variables	Conceptual Definition	Operational Definition of Terms	Dimensions	Indicators	Measuring Scale
Research Objective 1	Availability of ICT Resources	ICT resources used for teaching & learning of physics	A set of items for the physics teachers and students to identify ICT resources in their schools	• Desktop computers • Laptops • ICT room • Printers • Scanners • Projectors • Photocopier • Internet connectivity • Power supply • Smart board • Interactive screens	Yes = 1 and No = 0 for each dimension	Nominal
Research Objective 2	ICT integrated strategies	ICT strategies for physics instruction	A set of items in the questionnaires for identifying ICT strategies and methods for physics instruction	• Lecture method • Class Discussion Method • Experimental method • Question and answer method • Discovery method • Exploration method • Demonstration method	Yes = 1 and No = 0 for each dimension	Nominal

Objectives	Variables	Conceptual Definition	Operational Definition of Terms	Dimensions	Indicators	Measuring Scale
				• Group discussion method		
Research Objective 3	Attitude of Physics Teachers	The feeling of the physics of ICT use in the instruction process Perception of the physics teachers on ICT use in the classroom	A set of related items in the questionnaire on the feelings of the physics teachers on ICT use in teaching A set of items on the perception of physics teachers on ICT use in teaching and learning	• Ease of use of the ICT resources • Flexibility in using ICT resources • Administration supports ICT use in the school • willing to be trained on how to use ICT to teach • believe that the use of ICT can motivate learners • Management of learners' discipline when using ICT resources • ICT can make physics' abstract concepts easier for learners to understand • Teaching Physics using ICT	Likert Scale with indicators 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree and 5 = Strongly Disagree	Ordinal

Objectives	Variables	Conceptual Definition	Operational Definition of Terms	Dimensions	Indicators	Measuring Scale
Research Objective 4	Attitude of the physics students	Feelings of physics on ICT use in the instruction process Perception of the physics students on ICT use in the classroom	A set of related items in the questionnaire on the feelings of the physics students on ICT use in teaching A set of items on the perception of physics students on ICT use in teaching and learning	Ease of use of the ICT resources Flexibility in using ICT resources Enjoyment of the physics lesson taught using ICT resources ICT makes physics content easy to understand ICT enhances understanding of physics content Support the use of ICT resources in physics instruction school administration to buy more ICT resources	Likert Scale with indicators 1 = Strongly Agree, 2 = Agree, 3= Neutral, 4 = Disagree and 5 = Strongly Disagree for each dimension	Ordinal

3.7 Data Collection and Analysis

3.7.1 Data Collection Procedures

The physics teachers and students' questionnaires had four main types of measuring scales that included nominal, ordinal, interval, and ratio. Nominal scales categorize variables without hierarchy, such as gender and marital status. The ordinal scales ranked data in an order but did not specify the précised differences between values. The majority of the items had the ordinal scale variables, including the age, training years of the respondents, and attitude statements, and were ranked from strongly agree to strongly disagree. The interval scales were used to quantify the differences between data points with consistent intervals but lack a genuine zero point. These scales were used to categorize data without hierarchy, rank data, quantify differences between data points, and assess disparities between data points. The quantitative information gathered for this study was measured on a Likert scale. A multimodal technique was used to collect all the relevant information related study. The researcher briefed the respondents on the importance of the study to reduce non-response rates and to reach out to more respondents, particularly during regular school hours.

3.7.2 Description of Data Collection Tools

The data was collected using structured Physics teachers' and students' questionnaires and the Principal Interview Schedule. Questionnaires are a set of open and closed-ended tests that are used to collect information from physics teachers and students about their attitudes, opinions, and perceptions toward the use of ICT in the classroom. Structured questionnaires are easily measured on a ratio scale to provide correct information about the study. Structured questionnaires are frequently used in research surveys because of their high response rate from respondents and are very economical to the researcher (Creswell, 2008). The principal's interview schedule (PIS) was administered to the sampled principals to collect information about the status and use of ICT in the teaching and learning process. The qualitative data from the principals were integrated with the quantitative data from the physics teachers and students and analysed concurrently to enrich the research findings.

3.7.3 Data Analysis and Presentation

Data analysis is the process of interpreting data from written form to statistical form to show the importance of the study (Creswell, 2017). The process of data analysis was conducted independently for both qualitative and quantitative data that was collected from the respondents. Regarding the research objectives, data analysis included data editing and cleaning through inspection for completeness and consistency. The process of data cleaning involved checking of missing values, duplicates and outliers to enhance consistency of the data. The Statistical Package for Social Sciences (SPSS) computer program version 26.0 was used to process the cleaned quantitative data using descriptive and inferential statistics. The analysed quantitative data were presented using frequency tables, percentages and means. The purpose of descriptive statistics was to critically summarise the demographics of the respondents inform frequencies and percentages with respect to the variables in the research objectives.

The analysis of qualitative data involved familiarization of the collected data through repeated readings and coding of thematic statements. The qualitative data were coded, transcribed, and discussed as emerging themes in the subsequent sections. Thematics analysis was used in this study to identify, organize, and interpret specific patterns within the data. The findings of the qualitative data were corroborated with the results from quantitative findings to enrich the findings of the study. The analysis of the data was guided by the research objectives. The first objective was to assess the availability of ICT resources in secondary schools, and descriptive statistics involving frequencies, mean, and standard deviation were used to summarize the available ICT resources through corroboration of items from the research instruments. The data collected from the participants relating on the availability and utilisation of ICT resources computed using mean and standard deviation. The findings were tabulated to indicate the extent of use of ICT resources in secondary schools. The second objective on the ICT-integrated strategies for teaching and learning physics involved descriptive and inferential analysis of items from the research instruments. Composite averages were computed to determine the frequency of use on ICT integrated strategies by the physics teachers.

On the objective to establish the attitude of the physics teachers and students, items were measured on a Likert scale and analysed using descriptive statistics with triangulation of qualitative data from school principals. These involved using statistical parameters like mean and standard deviation to summarize, describe, and evaluate data, establish patterns, relationships, and trends in variables related to research questions. The qualitative data was coded and discussed as emerging theme in the subsequent sections alongside the findings of the quantitative data. The integration of qualitative and quantitative data in the findings was to enhance validity and credibility of the findings.

3.7.4 Summary of Chapter Three on Research Methodology

In this thesis, the mixed research approach was used to establish the factors influencing the use of the Information and Communication Technologies (ICTs) in the implementation of physics curriculum in Kenya. The purpose behind the choice of the strategy was the study problem that entailed the systematic determination of the variables that restrain the utilization of ICT in the secondary school to study physics. The study focused on the physics instruction methodology, availability and utilisation of ICT tools, and teacher and students' attitude towards the use of technology in teaching. The inspiration for the approach of scientific inquiry, as a mixed one, was also connected with the personal experience of the researcher. The mixed method presupposed gathering and interpretation of both numeric and non-numeric data through an extended period of time, with the use of more resources. The qualitative data was also significant in the triangulation process, where it guaranteed the presence of a point of convergence between the quantitative data of the physics teacher and the learners.

The descriptive research design was adopted to improve the validity and reliability of the research instruments and data collected. The tools were piloted in one secondary school within the study area, which had the same characteristics as other schools in terms of population sampled. Data collection licenses were sought from NACOSTI and the Ministry of Education in Kenya, in liaison with the school principal. The data collected by the tools were cleaned and entered into SPSS software for analysis through the correlation technique. The reliability coefficient for PTQ and PSQ was found to be 0.82 and 0.79, acceptable for the collection of data in the main study. The content and face validity of the research tools were ascertained by experts from Unicaf University with guidance from the supervisor. Face validity ensured that the instrument measured appeared to be assessing the constructs under investigation, while content validity ensured that the research tools contained all possible questions that could have investigated the constructs of determinants constraining the use of ICT in physics instruction. The study operationalized variables to clarify research objectives and remove ambiguities.

The analysis of data involved the transformation of the written data into a statistical format in order to reveal the significance of the study. It entailed editing and cleaning of information to perfection and processing of data using Statistical Package of Social Sciences (SPSS). The information was displayed as frequency tables, modes, and means, and coding, transcription, and discussion of the qualitative data according to the emerging themes. The quantitative and qualitative data were analysed simultaneously to identify the convergence and divergence points.

CHAPTER FOUR: PRESENTATION OF RESEARCH FINDINGS

4.0 Introduction

This chapter reviews the results of the study, especially on the reliability, accuracy, and significance of the insertion of ICT in the teaching of physics in the secondary schools. This data has been put in a logical way through the usage of frequency tables, figures, and charts, all of which led to an understanding of the outcomes. The interview schedule is supported by the quantitative information, with references to the qualitative information in the interview schedule. The mixed-methods method that was this study offered a wide understanding of the research issue because it enabled the simultaneous analysis of both qualitative and quantitative data. The strategy was critical in the formulation of an impression of the issues that impede the use of ICT in teaching physics in the secondary schools, especially in Nairobi County in Kenya.

The Information and Communication Technology (ICT), which has permeated the educational sector of the educational field in the developed world, has significantly transformed the teaching and learning methods of education, considering that they are now more interactive and less teacher-centred but learner-centred. This change promotes critical thinking, teamwork, and self-directed learning among the students. An example of this, is the application of ICT technology like simulation tools, interactive platforms, and learning software, which have aided the curriculum learning of abstract concepts in physics. Nevertheless, even though some advantages of the ICT in teaching are quite self-reinforcing, the Kenyan secondary schools continue to experience deficiencies due to the obsolete methodology and technique of teaching, extreme scarcity of resources, and the inability to access the newest technology.

The insufficiency of ICT infrastructure in schools is one of the major issues that was brought to reality in this research. The county of Nairobi has an excellent number of public secondary schools with no single basic ICT facility, like computers, projectors, or the internet. The unavailability of these educational resources greatly affects the capability of the teachers to embrace ICT in their teaching processes explicitly. Moreover, even where the resources to facilitate the implementation of ICT resources in schools are available, the implementation has not been carried out, as there are no proper in-service training and directions given to the teachers on the use of the technological tools. Thus, a good number of teachers continue with the old and traditional teacher-centred teach-back methods that have not yielded any significant results in capturing the attention of the students and the capacity of the students to have a more profound understanding of complex subjects, such as physics.

In addition, with the infrastructural issues, the attitudinal issues have also been found to be present in the study, and these issues have greatly affected the implementation of ICT in teaching physics. This negative attitude to the usage of ICT is also traced in the fact that several physics teachers are not constantly certain that they can apply the technology in classroom settings. This distrust is further compounded by the fact that there is no access to professional development opportunities that are geared towards ICT integration. Likewise, the attitude of the student to the application of physics and technology in learning is also a determining factor in the success of the ICT integration. A significant proportion of students hold the view that physics is a difficult and abstract subject, and this is aided by the traditional teaching philosophies that fail to render the subject interesting and easy to relate to.

The paper was to present and evaluate the major barriers that are inhibiting effective adoption of Information and Communication Technology (ICT) in teaching physics in high schools in Nairobi County in Kenya. Namely, the discussed study is spanned with the issue of barriers to infrastructure, teacher preparedness, administrative support, and attitude barriers to the application of ICT in teaching physics. The findings of the report help in informed policy responses of the Ministry of Education and strategic intervention to enhance ICT application, encourage the students to participate, and improve performance outcomes of physics learning in secondary schools. These challenges were intended to be met with the objectives of this study, which aim at giving a better understanding of its determinants that limit the use of ICT in physics teaching, and they are;

1. To determine the levels of access and use of ICT resources in secondary schools in teaching physics in Nairobi County, Kenya.
2. To examine the ICT-based teaching practices of physics instructors in high schools in Nairobi County, Kenya.
3. To investigate how the attitude of teachers towards ICT affects its application in teaching and learning of physics in Nairobi County, Kenya.
4. To explore how the attitude of students impacts on adoption and effectiveness of ICT in teaching physics in Nairobi County, Kenya.

These purpose of this study is not only to shed light on the issues of ICT integration in education, but also to suggest ways to which the use of ICT in teaching physics may be enhanced. The results imply the need for reforms in the policies, special investment into the ICT infrastructures, and teacher education. In addition, the research shows that the culture must be transformed in the aspect of the perception of teachers and students towards physics and the use of technology in learning. These issues give the chance to make the process of ICT implementation in physics teaching more positive, which will eventually lead to the improvement of grades and the enhancement of the knowledge possessed by the students in the given topic. The research questions have been employed to structure the findings of this study. The initial research question was to determine the access and utilization of the ICT resources in the secondary schools of Nairobi County in Kenya for teaching physics.

The research question was meant to determine whether the secondary schools in Nairobi County possessed ICT facilities and whether teachers were using the facilities to impart knowledge to the students. The resources that were analysed under ICT were as follows: computers and laptops/tablets, projectors, printers, photocopiers, scanners, internet connectivity, mobile phones, computer rooms/ICT rooms, teleconferencing facilities, physics educational software, storage media, digital content from KICD, interactive whiteboards, and digital cameras/camcorders. The physics students were expected to choose from the list of ICT resources using a tick (√) in addition to identifying the use of such resources in their respective schools to improve teaching and learning physics. Once again, the physics teachers and the principals were also supposed to state the ICT resources present in their respective schools by selecting the same ICT resources in their interviews.

The information is triangulable because the three respondents, who were the principals, the physics teachers, and the students, have provided the information that can be correlated to substantiate the validity of the findings. The findings of this research question were tabulated in frequencies, such that the most and least used ICT resources of the schools could be determined. The item in the questionnaire required the respondents to respond to the frequency at which they used the ICT resources and the outcomes were summarized in a bar chart to test the use of the ICT resources to deliver the content in physics using either PowerPoint, videos, simulations, or internet searches. The literature on the utilization of ICT resources in Kenya relative to Nairobi County also articulates the findings of this research question.

The second justification for conducting the research was to study the ICT-based teaching practices in high schools in Nairobi County in Kenya, among physics teachers. The research question was aimed at investigating the ICT techniques used by physics teachers to teach. The physics teachers were given the statements considering ICT strategies of teaching physics on a five-point Likert scale of SD- Strongly Disagree, D- Disagree, U- Undecided, A- Agree, and SA- Strongly Agree. The frequencies and percentages were employed to summarize the results, and the results were afterwards analysed in terms of the Mann-Whitney U test to ascertain the ICT strategies that male and female teachers of physics employed. The level of significance of $p < 0.05$ was set as the p-value used in the establishment of the importance of each statement. The structure of the findings as a discussion component of the narration was explained with references from the literature and accompanied by feedback from the interview of the school principals.

The third research question to be investigated was to consider the effect of teacher attitude towards ICT with regard to the use of ICT in teaching and learning physics in Nairobi County, Kenya. The research question was expressed in the form of a critical test, and that would be to determine the effect of the attitude of the physics teacher on the learning process of ICT integration. The questions to the physics teachers were based on their attitude towards the use of technology, and they were supposed to rate the statements based on their own perception using a tick (√) next to the statements. The results of this study were condensed in the frequency tables and narrated with the help of the findings attained in the main interview schedule. To present a detailed analysis of the attitude of the physics teacher in using technology in the instruction process, a chi-square test, which entails comparison of the observed and expected outcome to establish whether the difference that existed among the physics teachers was caused by chance or relation, was conducted.

The final study objective of the study was to examine the role of the student attitude towards the application and suitability of ICT applications in teaching physics in Nairobi County in Kenya. The primary objective of this research was to investigate the role of the attitude of physics students toward the ICT integration in the learning process. The answers provided to the physics students pertained to the attitude toward using ICT in the process of instruction and were rated using a Likert scale (Strongly Agree, (SA) to Strongly Disagree, (SD)). A frequency table was adopted to summarize the results to analyze the statements and measures of central tendency. They also compared the outcomes with the outcomes of the physics teachers since the physics teachers rated the attitude of physics students on the appearance of the ICT teaching process, and the outcomes were given in a table that indicated skew.

4.1 Trustworthiness of the Findings

Trustworthiness is a significant pillar of a qualitative study that determines the reliability, credibility, and validity of the research findings (Creswell, 2017). A mixed research design was employed in this study to explore the determinants of the discouraging factors to the use of ICT in the instruction of physics at secondary schools in Kenya. The synthesis of the qualitative and quantitative data allowed getting a deeper understanding of the issue in question and, thus, led to an increase in the validity of the observed findings. The mixed-method research design also improved the quality of data since Creswell (2011) and Madeira et al. (2019) observed that such research designs yield reliable, credible, transferable, and confirmable data. Each of these aspects were applied in this study to ensure that the findings credible, as discussed in subsequent section. To enhance the validity of qualitative data the following principles were strictly adhered to while collecting the data for analysis.

4.1.1 Transferability

According to Bell and Waters (2018), the degree to which the study findings can be applied or transferred to other contexts or situations is called transferability. It also has issues of the external validity of the study, in which the findings can be extended to other conditions not covered by the study. This method of triangulation in this study contributed to better transferability since data were collected through both qualitative and quantitative methods, which involved interviews with school principals, administration of a survey to physics teachers, and a questionnaire to students. This integrative method provided the fact that the results were not only representative of the particular sample but could also be extended to a larger degree to other parts of the county in Kenya that are already experiencing the same ICT integration problems.

The data obtained during this study was very rich and can be used to be applied in other schools of different types, like the public secondary schools of other cities or the rural schools that have inadequate ICT infrastructure. The study allows other researchers and teachers to draw a conclusion on how far they can generalize the findings in the research situation by giving a description of the research situation, such as the nature of the schools, the access to the resources, and the nature of the attitudes of the teachers and students. This is especially urgent in the field of education research since the possibility of generalizing the findings to another setting may be used to make decisions in policy and education reforms.

4.1.2 Credibility

Credibility refers to the level of research results and the capacity to answer the experience and view of the research participants as explained by Haq, et al., (2023). Credibility is rather important in qualitative research because it presupposes the trust in the fact that the results are valid and the conclusions made are based on reasonable data. In order to capture the credibility of the study, a series of data collection procedures was engaged and organized in the form of interviews, surveys, and classroom observations. The data could also be cross-tabulated, thereby decreasing the bias and enhancing the validity of the findings, since there were many techniques.

Secondly, the member checking process also contributed to the increase in credibility. Member checking refers to the act of releasing the research to the participants in a way that their opinions and experiences have been reflected correctly. The teachers and the school principals were also invited to this study to examine the outcomes of the interviews and give their feedback on whether such data were valid. It was just an affirmation of the findings, but it would make sure that any misunderstanding or misconception that may have existed is addressed before the actual analysis is performed. As stated by Liano and Hitchcock (2018), credibility is an important aspect of qualitative research because it is the factor that is needed to guarantee that the research addresses the actual reality about the experiences of the people involved and, therefore, makes findings more credible and valid.

4.1.1 Confirmability

Confirmability is the objectivity of the research result that can be tested in the sense that it cannot be based on the views of the researcher but on the existing data. In the qualitative study, one must prove that the outcome has not reflected the former conceptions of the researcher but the process and the views of the sample. This study was confirmable by careful data recording and analysis carried out as well as being recorded, and the interpretation was done based on the real responses of the interviewees.

The other of the most important steps that was undertaken to promote the confirmability of this study was the development of an audit trail. An audit trail is the chronicle of research procedure, data purchase proceedings, choices made throughout the analysis procedure, and clarification of rationale. This assists other researchers in replicating the actions that were utilized in the study to determine the accuracy of results and their validity. The findings made by this research were founded on the information gathered and could be established by other entities since there was a well-defined and transparent audit trail. Guba and Lincoln (1994) noted that confirmability is essential in assessing the objectivity and reliability of a qualitative study since it dictates that the results are evidence-based as opposed to being influenced by the subjectivity of the researcher.

4.1.2 Dependability

Dependability is the ability of the research findings to stay constant and unchanged in the course of time. A research study is claimed to be reliable where its findings can be reconstructed under different comparable conditions. Reliability in this study was achieved by the fact that the outcome of the research process was well documented, as were the methods used in data collection, the methods used in sampling, and the methods used in analysis. The study would give other researchers a chance to replicate the study in the same circumstances since the research process is clearly and transparently explained, therefore creating the reproducibility of the findings.

Triangulation with other variety of data analysis techniques were applied in this study to increase their reliability of the findings. According to Creswell (2017), triangulation entails cross-checking of two or more data or methods. This study involved a number of data sources, such as school principals, physics teachers, and students such the data were analysed both qualitatively and quantitatively. This has helped to understand the factors that inhibit the application of ICT to teaching and learning physics and also provides some form of consistency and validity of results across sources of information. The process of data was also saturated in order to make the data reliable. Data saturation happens when the data collection process is not generating information, and therefore, the data is sufficient to support the research findings. Data saturation in this study was reached when the subjects were ready to give enough information to answer the research questions, and the themes or the information that arose were not mandatory. This was fundamental in making sure that the result would be founded on a large and realistic dataset and improved the validity of the research.

4.1.3 Reflexivity

Along with the conventional characteristic of trustworthiness, the concept of reflexivity was also considered in the present study as a means of increasing the levels of trustworthiness and validity of the research results. Haq, et. Al., (2023) define reflexivity as the ability that the researchers possess in the manner in which they shape the study and their biases and assumptions. Reflexivity is equally significant in qualitative research because it can be employed to ensure that the research is not overly dependent on individual perceptions and experiences of the researcher.

Reflexivity has been applied in the concept development process of this study. The researcher was also keeping a reflexive journal where they took notes of their thoughts and feelings about the process of the inquiry. This was to determine and downplay the biases that would have affected the collection or analysis of data. The fact that they were perceived to be part of the research process provided the researcher a chance to ensure that the research findings were informed by the data they accessed and not their assumptions or preconceived ideas.

4.2 Triangulation of data

According Noble and Heale (2019) triangulation is a highly important procedure of the research when considering a research topic in any area of education, and it is conducted through different datasets, methods, theories, or investigators. The triangulation is likely to strengthen the research findings regarding the credibility, validity, and strength through the introduction of alternative approaches and views. The latter method could be especially useful in the context of educational research because a variety of data sources and opinions could be considered priceless in widening the knowledge concerning the complex phenomena. Triangulation enhances the chances of bias avoidance, and more subtle and legitimate interpretations of the research information can be made. Triangulation was initially introduced in other areas like trigonometry and geometry, whereby the method of establishing the position of a given individual was established by calculating the angles on two known points. This has changed in research, where the researcher can unravel the truth after comparing the information from various sources and approaches, and thus draw a deeper understanding of the problem under study.

Joslin and Muller (2016) claim that with the help of triangulation, one can view the problem of the research in a holistic manner since multiple perspectives are incorporated. The approach of the methodology will minimize the likelihood of bias and make the results more practical because it will entail the synthesis of the various opinions and sources of information.

Triangulation, on the other hand, is the mediation of evidence from various data sources, methods, theories, and investigators to confirm what the research was revealing. According to Denzin (2017), four major types of triangulations exist such as theory triangulation, investigator triangulation, data triangulation, and methodological triangulation.

All these forms are available to enable the research findings to be more credible and valid since they have a point of reference in which to cross-verify the information. Data triangulation is an information-gathering method whose basis is based on numerous sources, which are used to gain a wider and more improved insight into the topic of the study. According to Denzin (2017), the triangulation of data is necessary to make sure that the data collection procedure is comprehensive to cover as many dimensions as possible with time, place, and perspectives of the subjects. By relying on various sources and times, the researchers can acquire data that will assist in establishing patterns, contradictions, and complementarities of the data, which will assist in the more detailed process of analysis.

The information materials used in this study are three primary ones that comprise physics teachers, students, and school principals. These groups gave different facts on what dictates the use of ICT when teaching physics. The triangulation was only made possible since the information from these two divergent sources was pooled together, which enabled the well-founded viewpoint of possibilities and obstacles of ICT integration in secondary school education. In addition, data were also collected at various times based on the tool to be administered to the respondents, and this also contributed to the richness of the data. Indicatively, principal interview schedules were also used to compare information from the questionnaires of the physics teachers and students. This was staggered to stand a better opportunity of highlighting every group of respondents and also in helping to contextualize the responses in the course of data collection.

This study has not created any possibilities of overlooking any important information that could have been omitted in the event the research study had depended on a single source of information, because it has utilized the data offered by various angles. In this case, if the teachers had paid attention to the logistical element in the usage of ICT, the students could have paid attention to the degrees of engagement or interest in the learning process. Instead, principals had given opinions on administrative and policy issues.

The combination of the varying opinions allowed the study to have a broader picture of the impediments to ICT integration in the teaching of physics. This process of two or more researchers or observers is referred to as investigator triangulation so as to gather, analyze, or interpret data. The practice is used to minimize the chances of bias that can be elicited by a subjective interpretation on the part of a researcher. Inclusion of other investigators will also make the research process more objective, as an individual is able to collect and interpret the data using various perspectives. According to Denzin (2017), researcher triangulation will increase the plausibility of the study because the researcher cannot affect the research with his or her assumptions and biases.

The case study used investigator triangulation since the study developed a detailed data collection, especially considering the extensive geographical coverage and the number of sampled schools. The main researcher used to recruit and train other assistant researchers to assist in collecting the data. These assistants had been well trained on how they would carry out guided interviews without leading them and imposing their own conceived ideas. The process of data collection was equated across the various schools where this training was done, and all the researchers followed the same procedures.

Moreover, the research had a large sampling area, and the collaborative effort of several investigators was beneficial because they could do their work more efficiently. The interviewing with school principals through the measure of interviews and questionnaires with students and teachers was carried out with various team members. The specialization facilitated the gathering of data over a particular time, and not much was left out.

The other benefit of the investigator triangulation is that it enabled cross-checking of the data collected as well. Data analysis was done after the data collection stage by the aggregate researcher and the assistant researchers independently. This is because this independent analysis enabled a list of themes that recurred and inconsistencies to be established and discussed in totality. The various researchers were hired to assist in making sure that the findings of the study were not influenced by the interpretation and prejudice of one researcher, but rather by a disinterested and impartial view of the data.

The methodological Triangulation may be characterized by the fact that several approaches are used to research a similar question. The triangulation methodology can be used to overcome the strengths and shortcomings of a reliance on one research method by implementing the different methods of research. This study was conducted through the assistance of a mixed-method design, as qualitative and quantitative techniques of data collection were used. This was capable of making sure that the researcher obtained extremely rich and diverse information that could be cross verified to improve the power of the findings. The structured questionnaires that were applied during the quantitative part of the study did not exclude the teachers and students. These questionnaires were quantitatively defined with the topics of ICT resource supply, its regularity of use, and the attitude of teachers and students to ICT in teaching physics.

The positive use of the quantitative information was to determine the trends and patterns of which one is the correlation between the supply of ICT resources and the performance of the learners in physics. The qualitative aspect of the research entailed the employment of the extended interviews with the school principals, who gave the contextual information about the administration and policy-related issues brought about by the ICT integration. Such interviews also assisted the researcher to gain understanding of more specific impediments that schools faced, including budget constraints, training, and lack of infrastructure facilities. The qualitative data also elaborated on the quantitative patterns of data in the research problem by giving more perspective to the research problem. Triangulation of methods was done utilizing both qualitative and quantitative techniques to facilitate the process of making sure the research problem's depth and scope were reflected in the study. Although the quantitative data was a general representation of the impacts on the ICT usage in the context of teaching physics, the qualitative data helped to comprehend the obstacles and prospects the corresponding schools had in a more particular manner. Such a combination of methods minimized the risk of overreliance on a form of data, increasing the validity of the research in general.

Theory triangulation is considered the application of several theoretical perspectives in the explanation of the findings of the research process. As opposed to focusing on one theoretical perspective, theory triangulation urges the researcher to incorporate more than one perspective that will enable him or her to conduct a thorough analysis of the research problem. As noted by Flick (2018), theory triangulation helps the researchers to tackle complicated issues in other directions, and that is why it could be prevented because of the restriction of one theory.

In the present research, theory triangulation has been applied, in which multiple educational theories have been incorporated to present the variables of influence in the use of ICT in teaching physics. In the example of illustration, the constructivist theories of active learning and student-centered teaching were modified in determining how ICT could be applied in order to increase the engagement and comprehension of more challenging physics concepts by students. On the contrary, the behaviourist theories, where the emphasis is put on the power of reinforcement and repetition, were used in the effort to comprehend the process of ICT making concepts of physics memorable and acquirable.

This made it easy to apply the application of various theoretical frameworks that enabled the study to have a wider meaning to the findings of the research. The constructivist theories were used to comprehend the fact that ICT could offer critical thinking and problem solving, and the behaviourist theories emphasized the role of reinforcement in the learning process. This multi-theoretical approach gave a clearer picture of how ICT has been successfully implemented in teaching physics, as well as expounded on the numerous factors contributing to its success. The triangulation used was three matrices that resulted in the development of determinants that restricted the use of ICT in teaching physics according to the formulated research objectives. The triangulation matrix describes how the objectives and gaps of the research are solved, facilitating the data collection and analysis and providing the triangulation with validity, which is the cross-checking of the findings of various sources. The objectives of the research were aligned with each of the data collection methods, data sources, and data types, as demonstrated in the required table shown below in Table 6.

Table 6

Triangulation Matrix

Research Objective	Data Collection Method	Data Source	Type of Data	Triangulation Outcome
1. Assess the availability and usage of ICT resources in secondary schools for Physics instruction	Data from Physics Teachers' and Students' Questionnaires — frequencies, percentages of available ICT tools (e.g., computers, projectors, internet).	Data from Principals' Interviews describing resource adequacy, functionality, and maintenance challenges.	Physics teachers, students, and principals	Cross-validates quantitative findings on ICT availability with principals' explanations of

Research Objective	Data Collection Method	Data Source	Type of Data	Triangulation Outcome
				infrastructural and financial barriers.
2. Explore ICT-integrated teaching strategies used by Physics teachers	Questionnaire results using Likert-scale items; statistical tests (e.g., Mann-Whitney U) comparing male/female teachers' use of ICT strategies.	Interview responses from principals confirming or elaborating on how ICT teaching strategies are supported or constrained by school policy.	Physics teachers, principals	Merges quantitative evidence of ICT use frequency with contextual narratives on institutional and pedagogical practices.
3. Examine the influence of teachers' attitudes towards ICT on its use in Physics instruction	Quantitative ratings from teachers on attitude scales; Chi-square test results linking attitude to ICT use.	Qualitative interview statements reflecting teacher motivation, confidence, and training barriers.	Physics teachers, principals	Explains statistical attitude patterns through narratives — showing how confidence and support systems influence ICT uptake.
4. Investigate the role of students'	Students' questionnaire responses on attitude Likert scales;	Teachers' and principals' interview	Students, teachers, principals	Correlates student motivation

Research Objective	Data Collection Method	Data Source	Type of Data	Triangulation Outcome
attitudes in affecting ICT adoption and effectiveness	descriptive statistics of interest/motivation levels.	perspectives on student engagement and challenges.		data with teachers' and principals' qualitative observations to deepen understanding of learner engagement.

4.3 Analysis of Qualitative Data

The qualitative data analysis plays a role in the explanation of the information that concerns the ideas, values, and attitudes of the research object. The interview schedule formed the basis of a qualitative data collection since the sampled school principals provided qualitative data. The subjects were told the purpose of the study, and they were given a chance to sign a consent form in case they desired to take part in the research willingly. The data was captured by writing every detail expressed by the participants, and even where possible, the information was recorded if the participant agreed to sign the consent form allowing him/her to be recorded. To effectively analyse qualitative data, thematic analysis was chosen as the optimal and efficient approach for methodically identifying, organizing, analysing, and interpreting themes across the set of responses given by the participants (Clarke & Braun, 2014). Thematic analysis involves analysing textual qualitative data, such as interviews and transcripts, and identifying principal themes about the research aims. The theme analysis method enables the researcher to interpret the data collected in connection with life events and the research topic. The methods used in thematic analysis include familiarization, coding, topic development, and labelling of the individual themes in connection to the study goals.

The excerpts and the transcript of the guided interview were suitable data collection tools and would be used to set up the views, opinions, attitudes, and experiences of individuals on a particular issue under investigation. The researcher employed the latent approach to the reading between the texts in the form of a study framework in order to bridge the knowledge gap. The thematic analysis is also versatile and can be adaptable to the requirements of a study, and the findings of the research are credible and informative with minimal subjectivity. Analysis of qualitative data that occurred in this study regarding interviews was done in various stages that included preparation and transcription, coding and categorization, and analysis and interpretation. It has started with the transcription that involved accessing an audio recording of text transcripts. The familiarization process was performed through repeatedly reading the transcripts to find out the initial impressions and coming-out themes. A coding scheme is formulated, and the text in the transcripts is indicated and categorized into the section of interest. The transcripts were coded, and a code was assigned to the relevant phrases or sentences. New data continued to be analysed, which is why the coding scheme was being developed as well.

The interpretation and analysis entailed the identification of patterns and themes, breaking down the relationships between the themes, and interpreting the findings. It was created with a story to explain the identified themes and patterns. The analysis of the findings was explained in the illustrative quotes, the limitations of the study were identified, and tables/charts were included. The summary and the discussion of results were then ended with the conclusion, which was based on the quantitative research findings. The responses of the respondents have been explored attentively, and the common themes of the research have been determined with regard to the process of qualitative data analysis in the form of the thematic approach proposed by Clarke and Braun (2014).

While examining the qualitative data, the responses from each participant were coded as **P1** to **P25** since twenty-five (25) participants took part in the study. The responses from the interview schedules were coded to conceal the identity of the participant and enhance data confidentiality with strict adherence to the Data Protection Act of 2019, Clause 37 (1) which states that "*a data processor that uses personal data for commercial purposes shall, where possible, anonymize the data in such a manner as to ensure that the data subject is no longer identifiable*". Data-driven codes were created by the researcher in relation to research objectives, aims, and questions to generate ideas that are continuously repeated by all the participants. The guided interviews could take approximately 30 minutes, but some items could take more time depending on the probing questions that followed the main question.

4.4 Analysis of Quantitative Outputs

According to Stephanie (2016), "*Quantitative data analysis is the systematic examination and interpretation of numerical data*". Data analysis aids researchers in comprehending data by using statistical tests and mathematical calculations to discern patterns, trends, and relationships among variables. Both descriptive and inferential statistics were used to analyze the quantitative data collected on the questionnaire of the physics teachers and students. Descriptive statistics are used to provide a summary and description of data with the use of frequencies, means, and percentages. Rather, it is the inferential statistics of sample data that may be used to provide predictions and inferences about populations.

The sample's variables were described using frequency tables, while inferential statistics were used to generate predictions about the population based on the sample. The approaches utilised to analyse quantitative data were influenced by the study's goals and research issues. Both independent and dependent variables were included in the conceptual framework, which was used to analyse the study's variables. The underlying premise of the data collection procedure is that the intervening or confounding factors were controlled by the researcher to ensure that they did not have an impact on the independent variables.

4.5 Reliability and Validity of Data

4.5.1 Reliability of the Research Tools

According to Creswell (2017), the reliability of the research tool is "*the degree to which the tool can yield consistent or repeated results over repeated trials*". Therefore, reliability is the consistency of data collected by having the capacity to get the same findings again via the same methodologies. The research tools used in this study were piloted in one of the secondary schools within Nairobi County that was not involved in the main study. To enhance the reliability of the research instruments, a test-retest method was used to determine the coefficient of reliability.

To improve the reliability of the research tools, the researcher utilised standardised research tools by formulating structured questionnaires and interview protocols. The majority of items in the questionnaire were closed-ended, with a few open-ended, with suitable restrictions to interpretation. The test-retest method was employed to ascertain the reliability of the research tools. The method involved the administration of the research tools to the potential participants with similar homogenous characteristics twice within an interval of one week.

According to Drost (2011), test-retest reliability measures the consistency of the research tool when administered to the same population at different time points. The researcher ensured uniform administration of tools and consistent conditions for all interviews and surveys. The data collected from the PTQ and PSQ were cleaned and entered into the SPSS software version 26.0 for an in-depth analysis to determine the reliability correlation coefficient.

Cronbach's Alpha (α) of the research tools is the analysis of the internal consistency of the items and their suitability to scale to determine the research construct in the study. The alpha coefficient of reliability of PTQ and PSQ was already found to be 0.82 and 0.79, respectively. The article by Chakrabarti (2013) affirmed that the reliability of the research tools is the measure of consistency, repeatability, and credibility of the research findings of the same on the same homogeneous population on different occasions. The Principal Interview Schedule (PIS) entailed a set of strategies, which were to be employed to ascertain the credibility of the process, and which included the protracted engagement, the continuous observation, the triangulation, and the member checking. It was supported by the utilization of many data sources of educators and learners, or the mixed approach, to provide the results and enhance the validity of findings. The score that will be obtained from the tool should be the score that the tool was supposed to measure. It is interesting to note that when the coefficient of reliability is 0.7 or above, then the tool can be used to collect data (Mugenda, 2006). It was further noted that the acceptable score of reliability is 0.7 score and above (Jackson, 2015). Therefore, the reliability coefficient of the research tools employed in this study was more than 0.7 and acceptable in the data collection process.

4.5.2 Validity of the Research Tools

The research tools need to be valid before being applied to the actual data collection process of the study. Creswell (2013) explained that the validity of a data tool is when the tool is able to measure what it intends to measure. Triangulation in this study involved the use of several data sources, methodologies, hypotheses, or investigators to examine determinants constraining the use of ICT in physics instruction. Member verification involved respondent validation in which the researcher ensured that the principals were able to verify the correctness and reliability of findings. This method verifies that the researcher's interpretations correspond with the participants' experiences and viewpoints. The importance of member checking for this study was to identify misconceptions promptly to grasp principals' perspectives, even if they may dissent with the concept being studied.

The trust had to be built with the participants by asking them to provide feedback on the subject of the research and by valuing the input provided by the participants. It was also intended to promote the accuracy of the findings of this study by avoiding misinterpretations. The deep insights were also given by member checking, as the participants have an opportunity to contribute more information when their views are placed into perspective by the member checking. Finally, member checking was effective in making better decisions on the product since the design of this research was based on proven requirements and not assumptions or weaknesses.

Mudgal et al., (2026) in the discussion of "*Sample size estimation in mixed methods research: Balancing quantitative power and qualitative saturation*" noted that the objective is to augment the validity, reliability, and trustworthiness of findings by substantiating outcomes is to use diverse methodologies. This mitigates study bias and offers a more thorough comprehension of the research issue. A good measuring tool needs to be reliable and valid. Validity is more of the scrutiny of the content and the structure of the items in terms of appearance to measure the constructs of the study. The content and face validity of the research tools were ascertained by experts from UNICAF University with guidance from the supervisor. The face validity was meant to ensure that the instrument measured appeared to be assessing the constructs under investigation. The instrument was validated by a team of experts to ensure that it covers all key research objectives, including ICT availability, teaching strategies, attitude of physics teachers, and the students. The supervisor was able to identify unclear or ambiguous questions from the research tool amendments and discard the non-functioning questions.

The piloting of the research tools improved the validity of the content by restructuring and deleting some unnecessary questions that were not significantly contributing to the measurement of the constructs under investigation. According to Zohrabi (2013), validity is the trustworthiness and dependability of the research findings in qualitative research that involves the collection of that using interview schedules from the sampled secondary school principals. The content validity ensured that the research tools contained all possible questions that could have investigated the constructs of determinants constraining the use of ICT in physics instruction. It ensured that an adequate number of items were inserted in the questionnaires to conclusively address the issue under investigation. Construct validity was ascertained by a team of experts to ensure that the tools were able to accurately measure abstract concepts of the study that involved ICT integration in physics instruction.

The construct validity greatly linked the independent variables and dependent variable in relation to the conceptual and theoretical frameworks of the study. The findings of this study were further subjected to criterion validity for external benchmarks comparisons of data with similar characteristics of a homogenous population. The use of triangulation in data collection ensured that the data was sourced from different sources, like the physics teachers, principals, and the physics students, using different methods like questionnaires and interview guides. The varied methods used for data collection ensured cross-checking and validation of the study findings. Reliability ensured that the results were consistent and replicable, the errors in the results were reduced, and confidence in the data was elevated. In addition, it is also establishing confidence in the study outcomes. Validity, on the other hand, makes it right as represented by its ability to reflect on the concept being studied, which was the constraint on the use of ICT in teaching physics, therefore giving a precise description of the phenomenon under study. It can ensure that it leads to valuable outcomes that are relevant to the objectives of the research and informed conclusions. The principles of validity and reliability are addressed in a contrasting mode to each other to guarantee that the research results are credible and reliable in the most critical way to proceed with the knowledge development and make well-informed decisions in various sectors. Therefore, reliability and validity were used in collaboration to determine the credibility and reliability of the research results.

4.6 Data Analysis and Interpretation

4.6.1 Introduction

According to Creswell (2013), Data analysis "*is the process of examining, tabulating, categorizing, or restructuring the evidence to address the objectives of the study*". Furthermore, Braun and Clarke (2014) noted that data analysis is the systematic examination and interpretation of data by the application of analytical and logical thinking to detect and understand patterns, correlations, or trends. Therefore, the function of data analysis is to process raw data by filtering, adapting, and modelling to solve the research problem. Table 7 shows the response rate of the participants who were involved in this study. It was noted that slightly more than half of the male physics students participated in the study as compared to their female counterparts. Additionally, the data revealed a significant gender disparity among the physics teachers surveyed, with a majority of them being male. This suggests that a larger proportion of male students are pursuing physics teaching as a career pathway through higher education institutions. Notably, 52.0% (n=13) of the sampled school principals were female as compared to 48.0% (n=12) of the males, which supports the view of the Teachers Service Commission in Kenya about the staffing report (2022) that the majority of the secondary school principals are females, as shown in Table 7.

Table 7

Response Rate of the Participants

Participants	Gender	Frequency (N)	Percentage (%)
Physics Students	Male	138	55.2
	Female	111	44.4
	Prefer not to mention	1	0.4
	Total	**250**	**100.0**
Physics Teachers	Male	24	80.0

Participants	Gender	Frequency (N)	Percentage (%)
	Female	6	20.0
	Prefer not to mention	0	0.0
	Total	**30**	**100.0**
School Principals	Male	12	48.0
	Female	13	52.0
	Prefer not to mention	0	0.0
	Total	**25**	**100.0**

Note: *Number of Physics Students = 250, Number of Physics Teachers = 30, and Number of School Principals = 25*

Table 8a shows the biodata of the physics teachers who took part in the study. It was observed that 70.0% (n=21) of the schools sampled were mixed, while 20.0% (n=6) were boys' and 10.0% (n=3) were girls' schools. From the literature review, a significant proportion of secondary schools in Kenya do not have an adequate proportion of physics teachers. Therefore, the study also found that a significant fraction of the physics teachers had a teaching experience of less than 5 years since their graduation from teacher training colleges or universities as shown in Table 8b. This means that very few students select physics as their preferred training subject at the university level, and the few who train in teaching physics are employed immediately by the Teachers Service Commission after their graduation. According to a report on teacher shortages submitted to the National Assembly Education Committee in October 2024, by the Teachers Service Commission, it was emphasized that despite the efforts done by the government to narrow the gap of science teachers in the country, there is still a persistent shortage of physics teachers in Junior and Senior schools (Citizen Digital, 2024).

The Curriculum Based Establishment (CBE) developed by the Teachers Service Commission in Kenya mandates that each secondary school teacher must deliver a maximum of 27 lessons per week, equivalent to 18 instructional hours. In addition to teaching, teachers are also responsible for assessing students' continuous progress, attending departmental meetings, communicating with parents, and participating in co-curricular activities. From Table 8a, it was noted a half of the secondary physics teachers sampled had 13 to 19 instructional hours per week, and only 10.0% (n=3) of the Teachers had fewer than 3 hours of instruction every week. A proportional number of the sampled schools had more than one physics teacher, and this was due to the subject being compulsory for all students in Form one and two levels. It is important to note that the physics subject is optional in Form Three and Form Four, hence the number of physics students starts to decline from Form Three to Form Four levels of education.

Table 8a

Biodata of the Physics Teachers

Variable	**Indicators**	**Frequency (N = 30)**	**Percentage (%)**
School Category	Boys	6	20.0
	Girls	3	10.0
	Mixed	21	70.0
Teacher's Age Bracket	Less than 22 years	6	20.0
	22 - 29 years	9	30.0
	30 - 39 years	8	26.7
	40 - 59 years	7	23.3
Teaching Subjects	Physics & Mathematics	12	40.0
	Physics & Computer Studies	9	30.0
	Physics & Chemistry	9	30.0
Teaching Experience in Years	Less than 5	15	50.0
	5 - 10	6	20.0
	11 - 20	9	30.0
Number of Instructional Hours Per	Less than 3	3	10.0
	3 - 8	6	20.0

Variable	Indicators	Frequency (N = 30)	Percentage (%)
Week	9 - 12	3	10.0
	13 -19	15	50.0
Number of Physics Teachers in the School	2	11	36.7
	3	10	33.3
	More than 5	9	30.0

Note: *Number of Physics Teachers* ***(N) = 30***

Table 8a contains a detailed description of the demographic and professional qualities of those physics teachers who participated in the study and reflects such variables as the type of school, ages of the participants, the subject taught, the years of teaching experience, the number of hours the participants spent a week in school, and the number of teachers teaching physics in the school. The information can be quite educational on the teaching environment and experience, as well as the workload of the instructors in physics, which in the process affects their capability to incorporate ICT in their teaching practices.

These figures show that a high percentage (70.0) of the teachers were based in mixed schools, as against 20.0 in boys' schools and 10.0 in girls' schools. This means the wider background composition of the secondary schools in the Nairobi County, where the mixed schools are more prevalent. The sample is based on mixed schools, which assumes that such schools may be among the primary targets of ICT integration practices since such schools contain a sizeable proportion of students. In addition, the lower number of female schools is also a possible focus of the future study since the problem of gender inequality in science and ICT education is a significant challenge in most developing countries, such as Kenya.

Given the age of teachers, 30.0% (n=9) of the sample teachers were classified in the age range of 22-29 years, and this is the most common category, and the other age brackets of 30 to 39 years followed at 26.7% (n=8). Lastly, for the ag bracket of 40 to 59 years, the physics teachers were 23.3% (n=7). This relatively high proportion of the sample that young teachers occupy may be a positive indicator of the impact of the adoption of ICT, as younger teachers are more technologically inclined and willing to work with innovations in their classroom. At the same time, even the age of the teachers is predestined with the necessity to be attentive to the special professional development activities that might allow them to rectify the varying levels of digital literacy and provide the tools that will probably guarantee to the fact that all teachers, irrespective of their ages, should be able to use ICT to teach physics. This finding corroborates with the findings of Awuor and Okono (2022) that established that ICT integration in the teaching process enhances learner centred pedagogies that stimulate interest among learners to be engaged in the acquisition of relevant knowledge.

It was further noted that even though the sampled teachers were currently teaching physics, they were also teaching other subjects in the secondary curriculum that included Mathematics at 40.0% (n=12), Computer Studies at 30.0% (n=9) and Chemistry at 30.0% (n=9) respectively. At secondary schools, the two-subject model is used for teaching in the Science, Technology, Engineering, and Mathematics (STEM) subjects, where the teacher would usually be expected to teach two or more subjects because of the shortage of staff. This model presents challenges to the ICT integration and also opportunities. On the one hand, there can be an increased willingness of the teachers to utilize ICT in teaching physics, as they are most accustomed to computer studies. On the other hand, the extra labour required in the teaching of numerous subjects may not provide ample time and strength that educators can use in the integration of new technologies in their learning activities.

The teaching experience of the teachers in the study was below five years (50.0), 30.0 years of experience, and five to ten years of experience made up 20.0%. It is marked by the presence of a relatively high proportion of inexperienced teachers, and thus, it requires that continuous professional development be provided to guarantee that the teachers can become accustomed to ICT in teaching. The older teachers who might be rather conservative in terms of their teaching style might need to be specialized in terms of interventions that would result in their adoption of new technologies. Meanwhile, the older teachers who might be more accepting of innovation are to be trained and helped to utilize ICT in their classes.

Table 8a also contains information regarding the amount of time spent on instruction per week. Half of the sampled teachers (n=13) had 13-19 hours per week of instruction while 20.0% (n=6) of the teachers had the time of instruction between 3 and 8 hours. The low proportion of 10% (n=3) was made up of less than 3 or between 9 and 12 teaching hours. This change in the number of hours worked deserves a mention in the analysis of the obstacles facing the use of ICT, since teachers who have a greater workload might be taking a longer time to create and execute ICT-based lesson plans. On the other hand, those with less time on instruction are those who have more time to think over new instructions that involve the use of ICT. Lastly, the number of physical teachers per school also varied, with 36.7 percent of the schools having two physical teachers and 33.3 percent having three or more than five physical teachers, respectively. The imbalanced teaching of physics in schools means that the level of collaboration and sharing of resources among the teachers would be very heterogeneous and thus affect the overall performance of ICT integration. This may be because schools with more physics teachers will be able to share the best international practice as well as assist each other to embrace new technology better than those with few teachers. To acquire more knowledge on the role of demographics of the physics teachers on the use of ICT in the teaching profession, a chi-square test was conducted, and the results were tabulated as shown in Table 8b.

Table 8b

Summary of the Chi-Square Test Results for Physics Teachers' Demographics

Variable	χ^2 Value	df	p-value	Interpretation
Gender	10.800	1	0.001	Significant – Gender affects ICT perception
Number of physics teachers in the school	0.200	2	0.905	Not significant – No influence
Use of ICT in teaching physics	8.333	1	0.004	Significant – ICT users show more positive views
Age bracket	0.667	3	0.881	Not significant – Age does not affect ICT use

The Chi-square test was carried out to examine the variable of demographic and contextual variables on the use and perception of Information and Communication Technology (ICT) in physics education. The measured variables included gender, number of physics teachers in a school, actual use of ICT in teaching, and age groups of teachers.

The Chi-Square statistic demonstrated that the relationship between gender and ICT-related responses is statistically significant ($\chi^2 = 10.800, df = 1, p = 0.001$) which implied that gender does play a role in the perception and use of ICT when teaching physics by teachers. It was concluded in a similar way as Yusuf et al. (2023), noting that variations in access to digital resources, in addition to trust in the use of technologies, were often imbalanced between and within genders to influence the ICT adoption in science learning in unequal ways. This brings about the necessity of establishing gender-sensitive ICT training and support systems. There was no significant correlational relationship between the number of physics teachers in a school and the use of ICT ($\chi^2 = 0.200, df = 2, p = 0.905$). This implies that there is no influence of departmental size on the likelihood of ICT integration launching in teaching. Therefore, the number of physics teachers in a particular secondary school in Kenya does not necessarily influence ICT integration in the process of instruction. The results confirm the arguments made by Mwangi and Nyambane (2024) that personal motivation of teachers, teacher competence, and technology access are primarily driven by to use of ICT rather than institutional staffing and institutional structure. The real ICT usage and responses concerning its efficiency in instruction were also strongly correlated ($\chi^2 = 8.333$, $df = 1$, $p = 0.004$).

Active teachers who participated in the ICT use had a higher likelihood of reporting positive perceptions, even of the advantages of ICT in education, such as increased student comprehension and interaction. It corresponds to the report made by Adeyemi and Bello (2023), who emphasized the variation of positive attitudes and the likelihood of successful permanent integration with the assistance of the practical ICT experience. The responses concerning ICT were not statistically significantly related to age brackets of the teachers ($\chi^2 = 0.667$, $df = 3$, $p = 0.881$). This means that age does not play a significant role in the uptake of ICT in teaching physics. These findings are opposite to the past theses that younger educators are more likely to integrate technology and are consistent with the recent findings of UNESCO (2023), which indicate that training and support are more important variables in predicting ICT engagement than age. Table 9 provides the biodata of the school principals who took part in the study.

Table 9

Biodata of the School Principals

Variables	Indicators	Frequency (N = 25)	Percentage (%)
School Category	Boys	4	16.0
	Girls	5	20.0
	Mixed	16	64.0
Teaching Subjects	Biology/Chemistry	4	16.0
	History/Religious Education	9	36.0

	Kiswahili/History	4	16.0
	Mathematics/Physics	8	32.0
Duration of being a principal of the school	"1 - 3 years"	8	32.0
	"4 - 6 years"	4	16.0
	"7 - 12 years"	9	36.0
	"More than 12 years"	4	16.0

Note: *Number of School Principals Sampled (N) = 25*

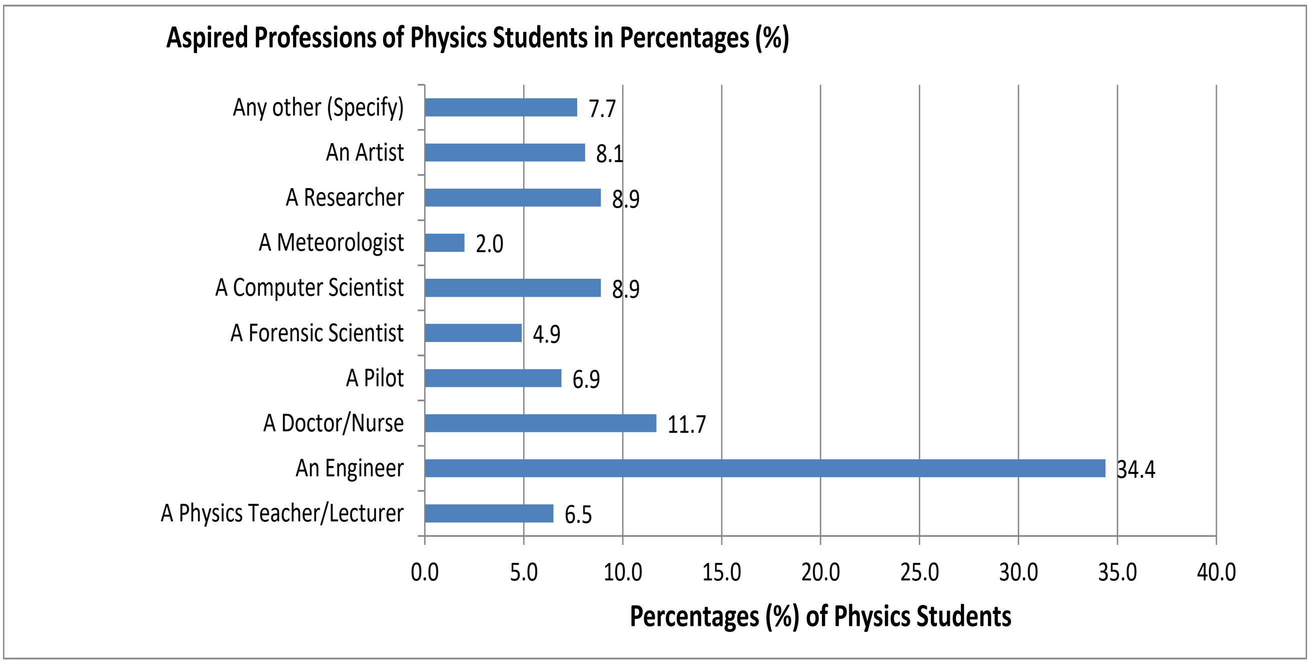
As indicated in Table 9, the biodata of school principals and their demographic and professional attributes are very sensitive in defining their capacity to make a positive impact on ICT integration in the education process implementation via the enforcement of government policies. It was also observed that most of the principals had 7-12 years or more of experience in schools as school principals. This implies that they were made aware of the government policy on the integration of ICT in education, and they are very much in support of the government initiative to ensure that their respective schools embrace technology in the teaching and learning process. The study findings justify the necessity of the particular interventions that should consider the specifics of the issues and opportunities that are predetermined by the types of schools, number of students and workload of teachers.

4.6.2 Professions Aspired by Physics Students

The study aimed to determine the career aspirations of form three physics students as they complete their secondary school education. Their aspired profession influences the use of technology in the instruction process, depending on what they want to do in the future. The rationale behind students' aspired profession is to establish the strategies that physics teachers use to motivate students to achieve their competencies and their preferred academic potentials. The analysis of the qualitative data established that physics topics such as *Linear motion, Waves, Magnetism, Optics, Newton's law of motion*, *Current Electricity*, *Measurement*, and *Electrostatics* were very abstract and difficult for the physics students to understand. The results of this investigation correlated well with the report released by the Kenya National Examinations Council (2023) about the declining performance in Physics examinations, showing that 50% of the students were scoring below the pass mark of 50 out of the possible 100 marks. Therefore, physics teachers need to make it clear on the objectives of the physics topics and use appropriate technologies to make the content easier for the students to comprehend. For instance, if they can show the students using a computer and projector that studying motion will allow them to fly an airplane or a spaceship and repeat that at the beginning of each lesson and through animation, the interested students will be more interested to learn. Teaching strategies like conducting virtual experiments, animations, and simulations to enhance understanding and retention of the physics content could motivate students. This would greatly motivate the physics students towards achieving their aspired professions, especially their future career prospects that require background knowledge in physics. The incorporation of technology in the instruction processes has a profound impact on the future goals and aspirations of physics students. Figure 4 shows professions aspired to by the sampled Form Three physics students.

Figure 4

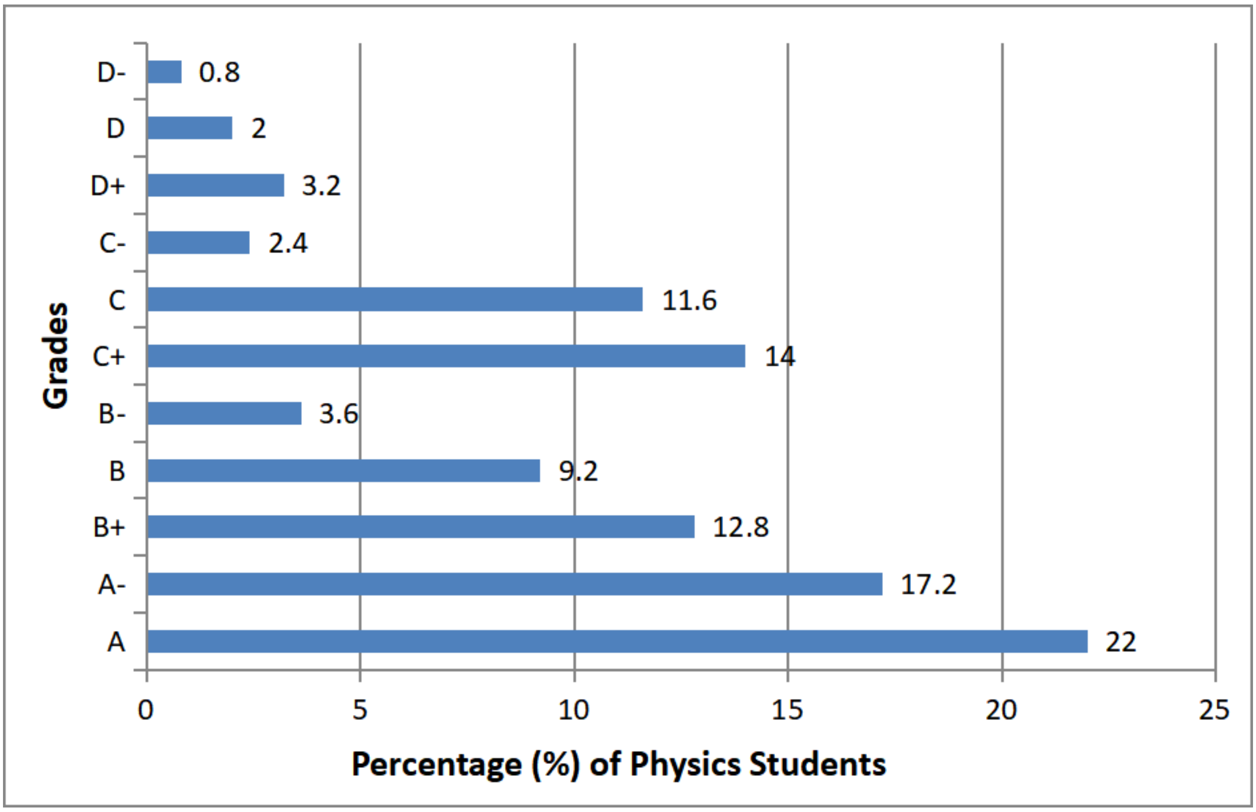
Professions Aspired by Physics Students



Physics students in Kenya frequently pursue professions in Science, Technology, Engineering, and Mathematics (STEM) disciplines, such as research, engineering, data analysis, and education. They may also seek positions in telecommunications, energy, or governmental institutions. The study established that a significant proportion (34.4%) of the physics students sampled prefer to become engineers once they complete school, as shown in Figure 4. Proportional numbers of physics students are aspiring to become doctors or Nurses at 11.7%, Researchers and Computer Scientists at 8.9% and 8.9% respectively. A relatively small proportion of physics students aspire to become meteorologists at 2.0% and other professional fields at 7.7%. Therefore, the incorporation of ICT in the instructional process is crucial for ensuring that physics students receive comprehensive training and acquire the necessary skills to reach their academic potential. The grading system in the Kenya Certificate of Secondary Examinations (KCSE) for students at the secondary level in Kenya ranges from grade A, which is equivalent to 12 points, to grade E, which is equivalent to 1 point.

Figure 5

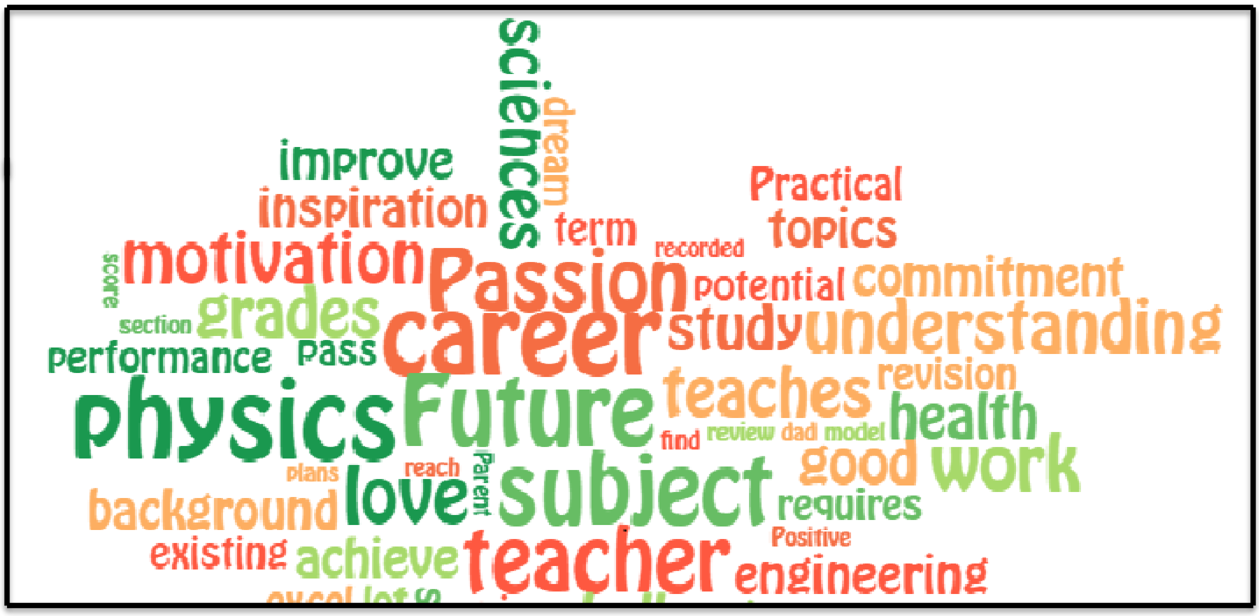
Target Grade for Form Three Physics Students in KCSE Physics Examinations



It was observed that 22% and 17.2% of the Form Three physics students aspire to score grade **A** and **A-** respectively, which are regarded as quality grades in the Kenya Certificate of Secondary Examinations (KCSE). Further to note is the proportional number of physics students who aspire to score lower grades like **C-, D+, D,** and **D-** at 2.4%, 3.2%, 2.0% and 0.8% respectively. The academic performance of physics students is significantly impacted by the instructional methods, school facilities, and their attitude towards the physics topics. Further, the study sought to ascertain what motivated the physics students to set the grades that they aspire to score in KCSE examinations, and the majority of them mentioned passion for physics and career requirements, as shown in Figure 6. The qualitative data from the physics students were analysed using the *Edwordle.net word cloud*. Ed Wordle is a tool designed for modifying "*word clouds*" that are created with Wordle. The first word cloud may be created either by analysing the incoming text or by retrieving it from an existing source and weighting it against other words to form factor components. It can modify the font, colour, size, position, rotation, and content of words in order to create personalised visual representations. The qualitative analysis from the Edwordle.net word cloud shows that the students set the targets based on the factor components such as Career (**1.00**), Future ambitions (**0.89**), Subject teacher (**0.87**), Passion (**0.76**), and Love for the subject (**0.70**). The least factor components that make them set targets included previous physics scores (**0.20**), application of the subject in their daily life (**0.20**), and role models (**0.20**).

Figure 6

Factors Motivating Physics Students to Set KCSE Grades Targets in Examinations



A proportional number of physics students were motivated by their physics teacher, and their parents and relatives. One of the physics students, coded **PS34,** said that;

"*I do enjoy and understand several topics and also the application questions; it is only a few topics that I find difficult, but I am sure that with the help of my teacher, I am going to reach my target*". Therefore, the physics teacher plays a crucial role in inspiring learners to achieve their maximum potential in physics examinations. Integrating technology in the pedagogy of instruction facilitates the comprehension of abstract topics for students by employing virtual experiments and real-life demonstrations. The Physics students would be able to visualize the real application of the subject in their daily lives.

4.7 ICT Resources Used by Physics Teachers for Physics Instruction

This study assessed the availability of technological resources in secondary schools in Nairobi County, Kenya, specifically for teaching science subjects like physics, encompassing software, computer networks, and satellite communications. One of the objectives of this study was to assess the availability and usage of ICT resources in secondary schools for physics instruction in Nairobi County, Kenya. Computer technologies allow users to create, analyse, access, and use information, data, and knowledge during the instruction process. The study findings established that, to some extent, the sampled secondary schools had ICT resources like computers and laptops/tablets, projectors, printers, photocopiers, scanners, internet connectivity, and an interrupted power supply, but they are not adequate for physics instruction. Table 9 shows that a significant proportion of physics teachers and students agreed that their schools have desktop computers, laptops, and tablets, but they are not adequate. The study by Ogot et al. (2018) indicated that "*The factors influencing the use of ICT included inadequate computers and lack of administrative support among others,*" which is incoherent with the findings of this study. Notably, the ICT devices are very few to be used for classroom instruction; hence, they are solely used for administrative functions. However, of concern is the proportional number of schools in which the physics students indicated having Teleconferencing room(s) at 10.0% (10), Physics educational software like SimPHY or MATLAB at 10.0% (n=17), and digital content from Kenya Institute of Curriculum Development (KICD) at 10.0% (17), Interactive whiteboard at 30.0% (75) and Digital camera or Camcorders at 0.0% (9). As seen in Table 10, the physics instructors and students agreed that most secondary schools in Nairobi County lack digital cameras or camcorders and teleconferencing equipment. This greatly inhibits the acquisition of 21st century skills that include digital literacy among the students as they exit secondary education.

Table 10

ICT Resources available in Schools for Physics instruction

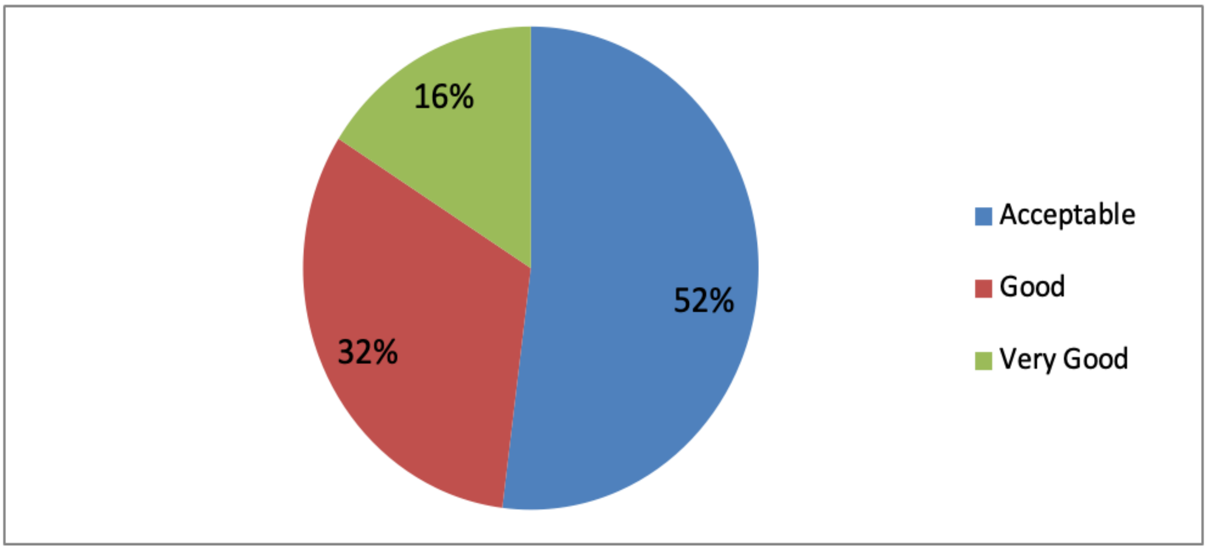
S/No	ICT Resources	Physics Teachers		Physics Students	
		Frequency (N = 30)	Percentage (%)	Frequency (N = 250)	Percentage (%)
1.	Computers and Laptops/Tablets	30	100.0	145	58.0
2.	Projector	18	60.0	141	56.4
3.	Printer	25	83.3	75	30.0
4.	Photocopier	27	90.0	76	30.4
5.	Scanners	24	80.0	56	22.4
6.	Internet connectivity	17	56.7	60	24.0
7.	An interrupted power supply	16	53.3	29	11.6
8.	Mobile phones	21	70.0	92	36.8
9.	Computer room	18	60.0	65	26.0
10.	Teleconferencing room(s)	3	10.0	10	4.0
11.	Storage media like Diskettes, CD-ROM, DVDs, Flash Disks, Hard Disks	18	60.0	66	26.4
12.	Physics educational software like SimPHY and MATLAB	3	10.0	17	6.8
13.	Digital content from KICD	3	10.0	17	6.8
14.	Interactive whiteboard	9	30.0	75	30.0
15.	Digital cameras or Camcorders	0	0	9	3.6

From the structured interview conducted by the researcher on the school principals, it was established that the majority of secondary schools have **five (5)** to **twenty (20)** computers that are used for teaching purposes. Further, it was also observed that a proportional number of schools do not have adequate ICT facilities like scanners, teleconferencing facilities, digital content from KICD, or in-house developed physics content that could be used to improve learning outcomes. One of the principals of the sampled schools said that "*the students are always ready to use technology, it will enable them to get more information from the internet, our schools do not have adequate computers for learning, and therefore the government needs to provide computers and internet to schools*" (A Male Principal, Nairobi County). The information provided by the school principals was consistent with the information offered by the Physics teachers and students. The output of this study resonates with Ongwenyi et al. (2023) findings, which revealed that the majority of schools had inadequate ICT resources. Similarly, the Form Three students reported a deficiency of essential ICT equipment and resources in their respective schools. The investigation found that a substantial proportion of teachers had insufficient access to ICT resources, resulting in the inability to use them effectively. In this study, the principals associated the inadequacy of ICT facilities in schools with budget restrictions, lack of funding, and increased enrolment in the current education system in Kenya, due to a 100% transition policy by the government.

The vast majority of principals indicated that the ICT resources were not in good working condition to facilitate the pedagogy process. Slightly more than half of the sampled schools indicated that they were provided with educational software from the Kenya Institute of Curriculum (KICD), which is mandated legally to develop curricula for all education levels below the University and conducts research. The majority of the school principals indicated that the source of power for operating the ICT devices was electrical, and a third of them indicated that they use solar energy. In the qualitative interview with school principals, a significant number of teachers had received training on effectively using ICT in the instructional process, but they were not using ICT due to constrained ICT resources. One of the participants mentioned that: "*The teachers are ready to use online practicals and conduct more research in emerging concepts within the syllabus of physics*" (A Female, Principal in Nairobi County). Figure 7 demonstrates that almost 52% of the teachers acknowledged having the ability or knowledge to integrate ICT resources into their lesson plans. Noteworthy is the small proportion of teachers (16%) who said that they are very proficient at using ICT devices. This implies that teachers have not been sufficiently trained or updated on how to successfully incorporate ICT into the pedagogy of learning physics.

Figure 7

Ability to use ICT Resources by Physics Teachers



The majority of physics teachers at 90.0% (n=27) reported receiving training on the utilisation of technology devices in the instructional process. Additionally, a considerable proportion of teachers mentioned that they incorporate ICT in their instruction process. The study established that half of the ICT resources within the schools were acquired through *Direct Purchase*, while others were acquired through *Donation* at 30% (n=9) and *Procurement* at 20% (n=6) respectively. The methods of acquisition of ICT resources are very important for the schools to have reliable tools that could serve them for a long time under minimal maintenance. Therefore, procurement would have been the preferred standard way of acquiring ICT resources for the schools to enhance accountability and efficiency.

4.8 ICT Integrated Strategies for Teaching Physics at the Secondary Level

The second objective of this investigation was to establish the strategies for incorporating ICT into physics education at the level of secondary schools in Kenya. Table 11 shows that a significant number of physics teachers use the *Discussion* and *Explanation methods* at 100.0% (n = 30) and the *Lecture* and *Demonstration* methods at 90.0% (n=27). Physics teachers need to diversify other ICT-integrated strategies for teaching that allow students to discover knowledge through research and experimentation. This observation was also noted in the study by Sengul (2024) and Song (2024) who agreed that majority of the secondary school teachers often used traditional teaching methods such as explanations and lecture methods. They also emphasized that question and answer method, use of experiments and demonstrations were the most common method used by the physics teachers for instruction.

Table 11

Strategies used by the Physics Teachers for Classroom Instruction

Strategies used for Teaching Physics	Frequency (N = 30)	Percentage (%)
I. Discovery and Exploration	15	50.0
II. Collaborative and Critical thinking	21	70.0
III. Lecture and Experimentation	24	80.0
IV. Lecture and Demonstration	27	90.0
V. Discussion and Explanation	30	100.0

The study found that Discovery and Exploration was the least utilised strategy by physics teachers for efficiently teaching physics subjects to their students. According to

Bloom's Taxonomy, evaluating and creating are the highest levels of measuring learners' knowledge, abilities, and skills, and this can only be achieved if the learners are allowed to discover and explore physics content through demonstration and experimentation. The majority of the school principals interviewed agreed with the physics teachers that they use lecture and experimentation strategies in teaching physics. In one of the interviews, the participant said:

"In this school, our physics teachers are committed to teaching physics; they use lecture methods and take students to the laboratory to conduct experiments. Physics students are also given classroom exercises and questions for revision" (A Female Principal from Nairobi County).

The Physics teachers need to conduct experiments using readily available materials and ICT-integrated resources to help students comprehend the physics content. The study found that a relatively low percentage of physics teachers utilize ICT resources to enhance the process of instruction. A Significant proportion of sampled school principals mention that the physics teachers have not been trained on how to manipulate and use ICT gadgets for the purpose of teaching, while others believe ICT devices should only be used for communication and clerical work in the offices and not for instructional purposes. Table 12 shows ICT-integrated strategies used for physics instruction.

Table 12

ICT-integrated Strategies used for Physics Instruction

S/No	Statements	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Exact Sig. [2*(1-tailed Sig.)]
1.	I teach Physics using ICT resources like computers/laptops and projects	27.000	327.000	-2.693	.007	.018[b]
2.	ICT provides interactive physics lessons	27.000	327.000	-2.693	.007	.018[b]
3.	I normally provide computer-based activities to learners during my physics lesson	63.000	363.000	-.509	.611	.667[b]
4.	I can teach physics using PowerPoint applications	72.000	93.000	0.000	1.000	0.997[b]
5.	I can provide a hands-on demonstration to my physics students	18.000	318.000	-3.298	.001	.003[b]
6.	I always use the internet effectively to download and upload physics content	18.000	318.000	-3.298	.001	.003[b]
7.	I can assess students using computer software like Excel and customized analytical software	40.500	340.500	-1.721	.085	.104[b]
8.	I can conduct experiments and demonstrations using computer simulations and animations	45.000	345.000	-1.527	.127	.174[b]
9.	I like teaching physics using technology devices	36.000	336.000	-2.198	.028	.065[b]
10.	I can prepare an ICT-integrated lesson plan	40.500	340.500	-1.814	.070	.104[b]

a. Grouping Variable: Select your gender (n_1 =6, n_2 = 24)
b. Not corrected for ties.

To better understand the usage of ICT strategies, a Mann-Whitney U test was conducted to compare the various ICT strategies used by male and female Physics teachers. A Mann-Whitney U test was conducted to determine whether statistically significant differences exist between male and female Physics teachers in Nairobi County. The results indicated that there was a statistically significant difference in ICT usage between male and female teachers in using ICT resources like computers/laptops and projectors **U** ***($n_1 = 6, n_2 = 24) = 27.0, p = .007$,*** which might indicate that if teachers have access to ICT resources, then they might use them as suggested by Abedi (2024). There is also a significant difference in perceptions of ICT's interactivity during Physics lessons among the teachers ***$U (n_1 = 6, n_2 = 24) = 27.0, p = .007$*** which mirrors the findings of Mutinda and Simiyu (2023) that found that some teachers might recognize the benefit of ICT while others might not due lack of exposure. There is a significant disparity in capability or confidence in providing hands-on activities to physics students among the male and female teachers ***$U (n_1 = 6, n_2 = 24) = 18.0, p = .007$*** and the confidence in using ICT resources could be linked to the support the teachers are given by the school administrators, as indicated by UNESCO (2022). The physics teachers who could easily download and upload physics content via the internet, which was significant for teaching ***$U (n_1 = 6, n_2 = 24) = 18.0, p = .007$,*** which indicates digital literacy among the teachers despite infrastructural barriers, as cited by CEMASTEA (2022) on poor internet access in public schools in Kenya. There was a significant difference in attitude toward teaching with technology with significant proportion of teachers indicating that they like teaching physics using technology devices ***$U (n_1 = 6, n_2 = 24) = 36.0, p = .007$*** which indicate that the positive attitude may be higher among male teachers as compared to the female physics teachers which can be supported by the study of Omondi et al. (2022) that emphasized the importance of teacher motivation using ICT tools for instruction purposes. Findings of the Mann-Whitney U test reveal that there are significant differences in the way ICT is implemented, particularly in the methods of teaching, the access of online material, and the involvement strategies, and therefore, the solution is that particular training, development of infrastructure, and change of attitude are needed to appropriately achieve the benefits of ICT in physics instruction in Nairobi. The results of the given study are in agreement with those of Ogot et al. (2018), who discovered that the level of proficiency in the area of ICT among tutors and learners stood at an insufficient level of 36.7. The fact that the technology resources are not available in the secondary schools renders the wide usage in the teaching process problematic.

Table 13 shows that physics instructors' attitudes regarding the use of ICT devices for learning physics were measured using a Likert Scale, starting from Very true to Very untrue. Likert Scales have been employed to assess the character and personality aspects of individuals (Likert, 1932). Consequently, they were modified to gauge the beliefs of physics teachers regarding the utilisation of digital technologies in physics training. The physics teacher's subjective viewpoint of the usage of ICT in education was converted into an objective measure by employing the Likert scale.

Table 13

Statements relating to the physics teachers' beliefs on the use of ICT devices in the teaching and learning of Physics in percentages

S/No	Statement	VT	T	ST	N	SU	U	VU
1.	The administration supports ICT use in the school.	60.0	20.0	10.0	10.0	0	0	0
2.	I am willing to be trained on how to use ICT to teach.	80.0	10.0	10.0	0	0	0	0
3.	ICT can provide an array of teaching methods	80.0	20.0	0	0	0	0	0
4.	I believe that the use of ICT can motivate learners.	90.0	10.0	0	0	0	0	0
5.	I can manage learners' discipline when using ICT resources.	50.0	20.0	30.0	0	0	0	0
6.	ICT can make physics' abstract concepts easier for learners to understand	90.0	0	10.0	0	0	0	0
7.	I do not like teaching Physics	0	0	0	10.0	0	36.7	53.3

S/No	Statement	VT	T	ST	N	SU	U	VU
	using ICT							
8.	The use of ICT has less importance in the learning of physics	0	0	0	0	0	43.3	56.7
9.	The use of ICT in teaching physics is a waste of time	0	0	0	0	0	33.3	66.7

Notes: ***VT***=*Very True,* ***T***= *True,* ***ST***= *Somehow True,* ***N*** = *Neutral,* ***SU*** = *Somehow untrue,* ***VU*** = *Very Untrue*

Table 13 explains the perceptions and the views of physics teachers concerning the use of ICT devices in teaching and learning physics. Such attitudes play crucial roles as they directly influence the level of readiness of teachers to adopt and employ technology in the pedagogical approaches. The statements found in the table consider a range of viewpoints on the benefits, problems and overall importance of ICT in physics education. The proportion of the teachers (60.0%) who strongly concurred that the school administration favours the use of ICT in schools was significant as well as 20.0% of them agreed and 10.0% of them were of contrary opinion. It means that the ICT integration in the sampled schools is rather well-administered, which is a promising indicator of the successful technology application in the classroom. ICT integration needs the backing of the administration since, in most instances, the adoption yields the resources, training opportunities, and institutional acceptance of the teacher to integrate new practices in the teaching profession.

There will be increased opportunities for teachers to feel empowered to use the new technologies at school where administrators are active in facilitating ICT use. The statistics showed that the majority of the teachers (80.0%) greatly agreed that they would also like to be trained on how to use ICT in their lesson teaching, 10.0% of them said that they would be willing, and 10.0% were neutral. This overindulgence in getting trained shows the readiness of teachers and that they are willing to accept ICT, provided that they get the necessary support and training. This finding is important as a result of the increased ICT competencies of teachers through professional development programs that are specially made to do this. The intentions to learn are also a good change since they indicate that teachers are conscious of the potential benefits of ICT in education, and they are ready to improve. In the same note, 80.0% of the respondents were categorical that ICT would be able to provide wide coverage of teaching practices compared to 20.0% of the respondents who concurred. This translates to teachers being aware of how far ICT tools can be exploited to enhance their instruction. The lessons can be implemented to be more interactive, engaging, and even personalized to the needs of the students through the implementation of ICT. Technology tools such as simulation, animation, and virtual labs can have a very significant influence on the process of how the students learn and acquire intricate topics in other fields of study, such as physics, where abstract concepts might be difficult to grasp. The attitude of teachers is an example of how ICT may help to change how physics is taught, in case it is put in place.

The proportion of teachers (90.0%) that highly agreed to state that ICT could be used in motivating the learners was found to be encouraging towards adoption of technology in the instruction process with only 10.0 disagreeing. Engagement and motivation of students through the use of ICT have been a key factor in the attainment of learning outcomes, as highlighted by this consensus. Application of ICT in teaching physics not only makes the lesson interesting but also helps students to engage with it in new and dynamic ways. This observation is in line with the available literature that illustrates the potential of technology in motivating learners in an attempt to make the learning process more interactive and applicable to their day-to-day lives.

Table 13 indicates that 50.0 percent of the total teachers strongly agreed that they could manage the issue of discipline among the learners when they used ICT resources, 20.0 percent and 30.0 percent agreed and were neutral, respectively. The classroom control issue can be a challenge to manage with the technology, since sometimes ICT can be a distraction to the learners. However, such an outcome shows that a high percentage of the teachers are confident in their ability to maintain primary discipline and attention in the classroom when using ICT. This highlights the necessity of the presence of classroom management strategies that can be enhanced with the help of technology learning environments. The remaining 10.0 percent agreed, and most of the teachers gave a resounding yes (90.0%) that ICT can assist in making abstract concepts of physics easier to learn for the students. This highlights one of the significant advantages of ICT usage in physics instruction, i.e., the capability to bring into reality the abstract concepts using visualizations and simulations. Because examples of such phenomena are the concepts of electromagnetism, energy transfer, or even wave phenomena, students might not be able to grasp the phenomenon with traditional learning methods.

ICT allows the teacher to model and offer an interactive model, simulating it by demonstrating it with concepts that are more comprehensible to the students. Interestingly, not all the teachers strongly agreed with the statement that I do not like teaching physics using the assistance of ICT; 36.7 percent were neutral, and 53.3 percent claimed that the statement was very untrue. This means that most of the teachers are not averse to the application of ICT in teaching physics, which is quite promising and indicates the successful application of technology in the classroom. The low neutral percentages, however, reflect the fact that some teachers may not be sure of the use of ICT, and that may be due to a lack of confidence, or they may not be well acquainted with the technology.

Similarly, the teachers were not in agreement with the statement that the use of ICT has less importance to the learning of physics and 56.7% strongly do not agree compared to 43.3%

who moderately do not agree. This means that the teachers strongly believe that ICT is a major learning tool for classroom instruction. Teachers realize that ICT can have a positive impact on the learning process as the lesson becomes more interesting and the students can understand complex problems. The considerable proportion of teachers disagreeing with the idea that ICT does not matter in education refers to the fact that teachers are not in good spirits with technology. Finally, the statement that the use of ICT in teaching physics is a waste of time was strongly disagreed (66.7%) and disagreed at 33.3% of the teachers respectively. This agreement also points out that teachers have a positive attitude towards the adoption of ICT, as the majority of them do not perceive technology as one that frustrates and consumes the time that would be well spent on teaching. However, they believe it to be a tool that can enable the learning process to be more efficient and achieve improved academic performance among the students. The findings confirm that the teachers were mainly positive in teaching physics with the use of ICT. The teachers understand that it has a pedagogical potential and are ready to be trained and assisted by the administration. Teachers are also enjoying the application of ICT in motivating with more easily, elaborating difficult matters and offering diversity to the learning process.

There are barriers and concerns in classroom management that only induce a degree of uncertainty towards classroom management in applying ICT in the classroom, which suggests that specific training on digital classroom management control strategies is required. The percentage of teachers who did not subscribe to the negative attitudes towards the incorporation of ICT in teaching was quite significant, in that the most negative statements about the incorporation of ICT were turned down by most of the teachers; this demonstrates that culture or professional shifts towards the incorporation of technology in teaching by physics teachers. The analysis of the data revealed that the teaching environment in Nairobi County in Kenya, was liberal and tolerant of ICT. The findings that are supported by the literature, among others, show that ICT may be a revolution in physics instruction when well-equipped with infrastructure, continuous professional development, and administrative encouragement. Interestingly, the future government programs should focus on the minor problems of discipline and further consolidate the ongoing use by providing technical and pedagogical assistance to the teachers. As indicated in Table 14, the attitude of physics teachers to the use of ICT can be described as rather positive, with the majority of teachers realizing the need for technology in improving physics instruction, which makes it efficient and interesting. However, it needs constant assistance and professional development in order that each teacher, irrespective of his or her experience and level of confidence, may take advantage of the ICT in teaching.

Table 14

Challenges faced by Physics Teachers while using ICT in the Instruction Process

S/No	Challenges	Frequency (N = 30)	Percentage (%)
1	Negative perception towards the use of ICT	03	10.0
2	Lack of digital content	11	36.7
3	Work overload by the teachers	11	36.7
4	Inadequate ICT skills among the physics teachers	14	46.7
5	Lack of a constant power supply	21	70.0
6	Inadequate use of ICT devices	22	73.3

In Kenya, there is a high proportion of secondary schools (73.3%) (n= 22) that have inadequate number of ICT gadgets. In addition, 70.0% (n=21) of these schools are facing intermittent power. The significant proportion indicates that the ICT resources in schools are insufficient to support the curriculum delivery. The education sector requires the assistance of the government to achieve SDG 4, which aims at providing inclusive education, social mobility, and poverty eradication. Njiiri et al. (2024) discovered that a considerable percentage of the said teachers in schools are moderately technology savvy. The technology enables teachers to perform their duties with the aid of the technology and additional training and retooling on how to use technology is very important.

It is possible that the negative impression of the usage has led to the low influence of ICT that physics teachers should use. The Teachers Service Commission (TSC) has also been successful in training and sensitizing teachers, and this has seen a significant change in the perception of physics teachers, who have been considered as not being unfavourable as noted by Kariuki et al., (2024). As a result, the majority of them are currently disposed to embrace the use of ICT in teaching. According to the principals, a relative proportion of the secondary schools are struggling to acquire the needed ICT resources to teach due to a lack of financial resources. The negative perception towards ICT use is low at 10.0% (n=3), indicating that most of the teachers are not against the use of ICT in teaching, and this shows that the teachers' beliefs are also shifting to the positive when the advantages are achieved, just like the authors found that Ertmer and Ottenbreit-Leftwich (2010) established. It should be mentioned that negative perception is not a major barrier anymore in this study, despite being a traditional barrier. The absence of digital content at 36.7% (n=11) means that there is an immense challenge such that there is an unavailability of instructions to be used in physics. This is because Tondeur et al. (2017) stated the importance of quality digital content in effectively integrating ICT, which contributes to the argument. Teachers may not be able to find curriculum-based content or simulations that could apply to their individual syllabi.

The workload is 36.7% (n=11); that means that the teachers are overworked with their own workload in such a way that they do not have much time to learn or implement ICT tools. These echo the findings of Buabeng-Andoh (2012), which reported the scarce time and the overwhelming workloads and responsibilities of teaching to be the primary hindrances to the execution of ICT, especially in the resource-strained environment. The inability to use ICT tools is an obstacle, as the ICT skills rating is weak at 46.7% (n=14). Under this kind of attitude, teachers lack the technical confidence or training on the effective use of ICT in the learning process. This is why the study done by Kozma (2005) and UNESCO (2019) also focuses on the fact that meaningful ICT integration must be achieved through teacher training and retooling.

The lack of accessibility of normal power supply at 70.0 percent is a major issue in the infrastructure, and this has an effect on the proper inclusion of ICT in teaching physics. This was common in emerging circumstances, where power is not at all times available to utilize ICT. Oye et al. (2012) present the findings and mention the power and connectivity as the key circumstances of ICT-based teaching. The major challenge that was most indicated during the use of ICT to teach physics was the insufficient ICT devices at 73.3%. More than half (50 percent) of the respondents indicated having little access to computers, projectors, and smart boards, in addition to lacking internet as a barrier to ICT integration in learning.

The data related to these findings was also supported by the information gained during the main interview in case one of the principals of the schools answered, "*My teachers are willing to use ICT in the teaching process; the biggest problem is that the school does not have the computers and laptops, and the school has not got the internet because it is provided by the government...*" (*A principal in one of the schools in Nairobi*). This showed the lack of equipment to be a serious obstacle since it is congruent with Bingimlas (2009), who found the infrastructure disparity to be one of the primary factors explaining the slowness of introducing technology to the classroom. In general, the motivation and affirmation of teachers towards using ICT in the instruction process is rather high, but the implementation of the method is hampered by several critical problems, the most immediate of which are infrastructure (power and devices) and a deficiency of skills and resources that restrict the successful introduction.

The teachers will also require retooling so that they become knowledgeable and skilled to facilitate the teaching and learning process using technology.

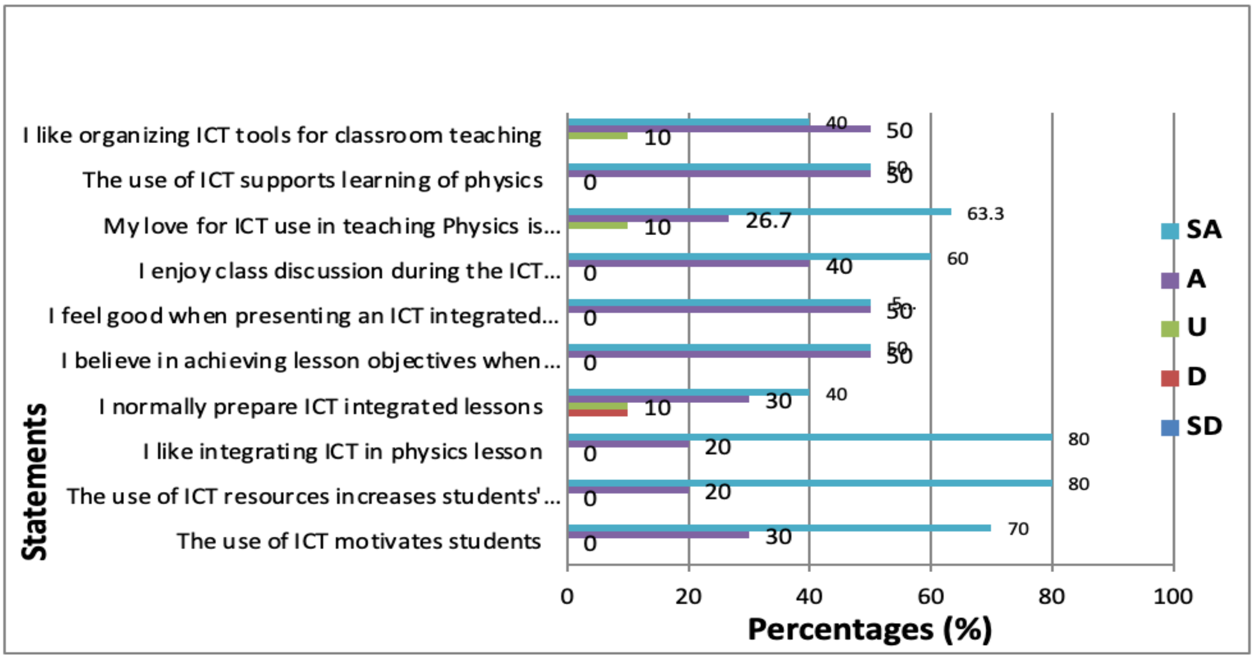
4.9 The Attitude of Physics Teachers on the Use of ICT in Physics Instruction

The attitude of the teachers greatly affects the effective usage of technology in the education sector. Therefore, the investigation of Njiiri et al. (2024) on the "*Teacher-Related Factors Impacting the Integration of Information and Communication Technology in Teaching in Public Secondary Schools in Naivasha Sub-County, Nakuru County, Kenya"*, noted that teachers had a moderated attitude toward the use of technology. This study aimed to investigate the attitude of Physics teachers towards the utilisation of technology in the instruction process. Figure 8 presents statements regarding the stance of teachers of physics on the utilisation of ICT in the instruction process.

The scale was divided into five ranges: **1.0 - 1.80** for Strongly Agree (SA), **1.81 - 2.60** for Agree (A), **2.61 - 3.40** for Neutral (N), **3.41 - 4.20** for Disagree (D), and **4.21 – 5.0** for Strongly Disagree (SD). The ranges of values were used to decide for each statement relating to teachers' attitudes on the use of technology in the pedagogy process. The study established that the majority of the sampled Physics teachers, having a **mean = 1.90** and a **SD = 1.155,** strongly disagreed that they could teach physics using ICT resources like computers, laptops, and projectors. Further, they believed that ICT provides interactive physics lessons within the learning environment, but they cannot be able to conduct experiments using computer simulations and animations. Subsequently, a significant proportion of physics teachers were in agreement that they could provide "*computer-based activities to learners during physics lessons, they can teach physics using PowerPoint presentations, they can assess students using computer software like Excel and customized analytical software, and they can prepare an ICT-integrated lesson plan"*. Figure 8 shows physics teachers' attitudes towards the utilisation of ICT in teaching.

Figure 8

The Attitude of Physics teachers on the use of ICT for physics instruction



According to Figure 8, a significant majority of physics teachers (80%) strongly agreed that the utilisation of ICT resources enhances students' interest in learning. Additionally, the same percentage of teachers expressed a preference for incorporating ICT into their physics lessons. A significant number of physics teachers, namely 70.0% of them, strongly agreed that they typically create lessons that integrate information and communication technology (ICT). Additionally, 90.0% of these teachers expressed a preference for organizing ICT tools for classroom teaching, while 50% of physics teachers were confident in their ability to meet class objectives with the integration of ICT in education.

The bar chart in Figure 8 shows the attitude and the perception of the physics teachers concerning the use of Information and Communication Technologies (ICTs) in teaching. The statements relating to the constructs were measured on a 5-point Likert scale from Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD). With the advent of Information and Communication Technology (ICT) in the learning process, it has assumed the centre stage in the current-day pedagogy, especially in the science subjects such as physics. The study has discussed the perception of physics teachers regarding the use of ICT in the classroom, which was conducted through a survey through the application of a 5-point Likert scale. Most of the respondents unanimously testified that ICT has a positive impact on student engagement and learning. In particular, 80 percent of the respondents highly agreed that ICT resources promote understanding, with 70 percent of the teachers also agreeing that ICT motivates students. This concurs with the findings of Yusuf et al. (2023), who found that the cognitive performance of learners taught physics through ICT-based instructions improved.

Moreover, the teachers stated that they enjoyed preparing ICT tools on their own and that they directed ICT-integrated lesson class discussions at a high compliance of 60 percent. These findings can be corroborated with the findings of Mwangi and Nyambane (2024), who attributed the same eagerness to the presence of a greater number of pedagogical training and digital literacy programs in schools. Nevertheless, in the case of positive attitudes, only 30% of all teachers strongly supported the notion that they were intending to use ICT-integrated lessons regularly. Such a missing element of the ideology and action is one of the manifestations of long-term issues, including time insufficiency and insufficiency of the infrastructure (Adeyemi and Bello, 2023). However, of interest to note is that when 63.3% of the respondents answered by stating that they would strongly agree with the statement that I like the use of ICT in teaching physics, 26.7% also strongly agreed with the statement, and this indicates that they found the use of ICT in teaching physics to be of great value, and the statement was also based on the practical value of the teaching concept of physics.

In brief, it was found that the attitude of physics teachers towards ICT use was very positive. There is, however, a high difference in the perceived effectiveness and use in lesson preparation. The infrastructural and professional gaps in the development will be bridged to ensure that there will be more coherence in the ICT integration. Similar to the findings, UNESCO (2023) suggests that teachers should be empowered to use technology as they deem necessary to simplify the instruction process. To derive a profound insight into the way the physics teachers viewed the application of ICT in teaching, a chi-square test was applied on the categorical data to determine whether there was a statistically significant relationship that existed between the variables or whether there was a statistically significant difference between the observed frequencies and predicted frequencies. The Chi-square enabled the researcher to make a conclusion about populations through sample data. Table 15 demonstrates the attitude of the physics teachers to the ICT use in the instructional process.

Table 15

Perception of physics teachers on the use of ICT in the instructional process

S/No	Statements	Chi-Square	df	Asymp. Sig.
1	The use of ICT motivates students	4.800[a]	1	0.028
2	The use of ICT resources increases students' interest in learning	10.800[a]	1	0.001
3	I like integrating ICT in physics lessons	10.800[a]	1	0.001
4	I normally prepare ICT-integrated lessons	9.000[b]	3	0.029
5	I believe in achieving lesson objectives when ICT is used to aid teaching	.000[a]	1	1
6	I feel good when presenting an ICT-integrated lesson on a PowerPoint	.000[a]	1	1
7	I enjoy class discussion during the ICT-integrated lesson delivery	1.200[a]	1	0.273
8	My love for ICT uses in teaching Physics is amazing	13.400[c]	2	0.001
9	The use of ICT supports the learning of physics	.000[a]	1	1
10	I like organizing ICT tools for classroom teaching	7.800[c]	2	0.02

The Chi-square test compared the observed and expected data in order to determine if the differences among the physics teachers were due to chance or a relationship. The findings indicated that there was a significant association between gender and perception of physics teachers on the use of ICT in the instructional process, $\chi^2 (2, N = 30) = 10.80, p = 0.001$. The findings indicate that physics teachers like integrating ICT in physics lessons as well as organizing ICT tools for classroom teaching. The study established that physics teachers have a positive attitude towards the integration of ICT in physics instruction. Subsequently, they get a sense of satisfaction while delivering a lesson that incorporates ICT through a PowerPoint presentation. They were also in consensus that the utilisation of ICT enhances the understanding of physics. The results of Ndihokubwayo et al. (2020) agree with these findings since they found that Rwandan physics instructors perceive electronic teaching tools as valuable and that their utility is consistent among teachers. Teachers must have a comprehensive understanding of technical, pedagogical, and subject matter.

4.10 The attitude of Physics students towards the usage of ICT in Physics Instruction

The term attitude encompasses the process of perceiving, comprehending, and interpreting something (Bordoloi et. al., 2021). The attitude of physics students towards the utilisation of ICT resources plays a crucial role in inspiring them to reach high levels of academic success. Ogot et al. (2018) noted that learners' attention improved, students became more engaged in reading and learning, overall student performance was better, and instructors' competency in using technology was boosted. The student's attitude towards ICT is very important in effectively incorporating technology into the learning of physics. Whether their attitude is favourable or negative, it greatly impacts the obstacles associated with using ICT in education. Table 16 displays remarks regarding the perception of physics students on the utilisation of ICT in education.

Table 16

Statements relating to the attitude of Physics Students towards the use of ICT in the instruction Process

S/No	Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)	$\bar{x}$	SD
1.	I enjoy the physics lesson taught using ICT resources like computers and projectors	52.5	33.2	8.4	2.5	3.4	***1.71***	***0.966***
2.	Our physics teachers like using ICT resources	20.8	20.3	21.2	13.0	24.7	***3.00***	***1.470***
3.	Interactive media makes physics content easy to understand	56.8	27.5	7.2	3.4	5.1	***1.72***	***1.078***
4.	I can understand physics content if taught using ICT resources	58.4	26.4	9.1	2.1	2.1	***1.59***	***0.894***
5.	I support the use of ICT resources in teaching physics and conducting experiments	65.2	22.7	8.2	0.9	3.0	***1.54***	***0.910***
6.	The use of ICT devices does not make me indiscipline	47.1	19.3	10.5	7.6	15.5	***2.25***	***1.491***
7	I want the school administration to buy more ICT resources, like computers and projectors	75.8	17.1	5.4	0.8	0.8	***1.34***	***0.696***

Note: ***SD*** = *Strongly Disagree,* ***D*** = *Disagree,* ***N*** = *Neutral,* ***A*** = *Agree,* ***SA*** = *Strongly Agree,* $\bar{x}$ = *mean and* ***SD*** = *Standard Deviation*

According to the findings in Table 16, the majority of physics students expressed a desire for the school administration to purchase more ICT equipment to be used for learning purposes. The students strongly support the use of ICT resources in the teaching of physics and conducting virtual experiments. They also believe that they can easily understand physics content if taught using the current technology. Furthermore, they enjoy physics lessons that utilize ICT resources like computers and projectors. Lastly, the students believe that interactive media makes physics content easy to understand.

The other fact that should be mentioned is that a significant share of teachers who use ICT tools do not enjoy using them (***mean = 3.00, SD = 1.470***), and this may also overwork the teachers. The occurrence of disciplinary cases may be brought about by the use of ICT devices in physics learning, with an average of 2.25 and a standard deviation of 1.491 to represent a large proportion of the physics students. The researcher created a second study of the attitude of the physics learners to the usage of ICT in physics learning, thus, via the prism of the physics teacher. These results were supported by Muchlis et al. (2023), who suggested that to implement the process of mastering mathematical thinking skills in the students, the technology was to be utilized in order to ensure the positive and active involvement of the students in the process of solving mathematical problems. Table 17 presents the statements that describe the Physics Students' perceptions, as evaluated by their teachers, on the utilisation of ICT in teaching, rated from Strongly Agree (SA) to Strongly Disagree (SD).

Table 17

Physics Students Attitude as rated by their teachers on the use of ICT in Teaching in Percentages

S/No	**Statement**	**SD**	**D**	**U**	**A**	**SA**	**Mean**	**SD**	**Skewness**
1.	The learners enjoy the ICT-integrated lessons **(S1)**	0.0	0.0	0.0	70.0	30.0	1.70	.466	-.920
2	The learners actively participate in the learning process **(S2)**	0.0	0.0	10.0	50.0	33.3	1.78	.641	.222
3.	Learners maintain discipline during the delivery of an ICT-	0.0	0.0	0.0	60.0	40.0	1.60	.498	-.430

S/No	Statement	SD	D	U	A	SA	Mean	SD	Skewness
	integrated lesson **(S3)**								
4.	Learners can easily manipulate and use ICT tools for learning **(S4)**	0.0	10.0	10.0	50.0	30.0	2.00	.910	.883
5.	The use of ICT increases the learner's concentration span of the lesson **(S5)**.	0.0	0.0	0.0	70.0	30.0	1.70	.466	-.920

***Notes; SD** = Strongly Disagree, **D** = Disagree, **N** = Neutral, **A** = Agree, **SA** = Strongly Agree,* $\bar{x}$ *= mean and **SD** = Standard Deviation*

From Table 17, it was noted that the attitude of the physics students greatly affects the use of ICT in the learning process such that the majority of the physics teachers were agreement that the students enjoy the ICT-integrated lessons and participate actively in the learning process, students maintain discipline during the delivery of an ICT-integrated lesson and the use of ICT in the teaching process increases learner's concentration time during lesson delivery. Further, it was observed from Table 14 that the statements were negatively skewed "*The learners enjoy the ICT-integrated lessons"* **(S1),** "*Learners maintain discipline during the delivery of an ICT-integrated lesson"* (S3), and "*The use of ICT increases the learner's concentration span of the lesson*" (S5) were found to be **-.92, -.43,** and **-.92,** indicating that the students had positive attitude towards the use of technology in physics instruction.

Additionally, it was observed that the statements "*The learners actively participate in the learning process"* **(S2)** and "*Learners can easily manipulate and use ICT tools for learning"* (S4) about physics students' attitudes towards using ICT in the teaching of physics were positively skewed, indicating that the use of ICT actively motivates them.

The distribution of data in Table 14 shows that students may be motivated to learn using ICT if they have the requisite skills on how to use and manipulate ICT devices. The physics teachers should also have the technological skills to effectively integrate technology in their delivery of physics lessons. These findings resonate with the findings of Njiiri et al. (2024), who established that the relationship between ICT and education has shown the need to acquire knowledge about ICT and its effective utilisation to enhance the integration of new technology in teaching and learning. Table 18 shows statements relating to reasons why the sampled physics students perceive that they might not perform well in the forthcoming Kenya Certificate Secondary Examinations KCSE in the physics subject.

Table 18

Reasons that might make Physics Students do not perform well to their Expectation in KCSE

S/No	**Reasons**	**Frequency (%)**		**One-Sample t-Test**			
		No	**Yes**	**t**	**df**	**Sig. 2-tailed**	**Mean Difference**
1	Physics teachers use very difficult methods to teach	83.2	16.8	7.091	249	.000	.168
2	The physics content is very difficult to understand	76.2	23.8	8.781	247	.000	.238
3	I do not like the physics subject	98.8	1.2	1.739	249	**.083**	**.012**
4	I do not like the physics teacher	93.2	6.8	4.262	249	.000	.068
5	The subject has a lot of mathematical calculations	59.2	40.8	13.100	249	.000	.408
6	The school does not have enough resources for teaching physics; hence no experiments are done	70.4	29.6	10.232	249	**.000**	**.296**
7	We do not have a qualified physics teacher	97.2	2.8	2.678	249	.008	.028
8	Lack of application of the	58.4	41.6	13.31	249	.000	.416

S/No	Reasons	Frequency (%)		One-Sample t-Test			
		No	Yes	t	df	Sig. 2-tailed	Mean Difference
	subject to my daily life activities			8			
9	I have changed my career ambitions, and it is not related to physics	91.6	8.4	4.778	249	**.000**	**.084**
. 10	The physics syllabus has not been taught	95.6	4.4	3.385	249	.001	.044
. 11	I normally don't prepare for physics examinations	60.8	39.2	12.670	249	**.000**	**.392**

Note: **t** = test statistic, **df** = degrees of freedom

Table 18 provides a comprehensive analysis of the factors that contribute to the underperformance of physics students in the Kenya Certificate of Secondary Education (KCSE) examinations. The causes given by students refer to diverse issues like the complexity of the material covered in the subject and other extracurricular issues like the unavailability of resources and teaching methods. The weight of each reason was open to the one-sample t-test that was conducted, keeping in mind that it was a factor that contributed to the failure to meet the expectations of the students as per performance.

The very difficult methods of their instructors to teach physics were excusable among students (16.8) in an insignificant percentage, and such a t-test (*t = 7.091, p = .000*) value was regarded as significant. Although this constituted only a very small percentage of the students who attributed their underperformance to the teaching methods, the fact that the result is significant makes the issue of the overly complex teaching methods still something to be considered in the manner in which the students learned and comprehended the concepts in physics. The strictness of the teaching can also be supplemented with the abstract character of the topic that may need additional student-oriented interventions like problem-based learning and ICT-based illustrations to simplify the ideas and make them easier to grasp.

The percentage of the respondents who reported that the subject content of physics is challenging to comprehend (23.8) is statistically significant (*t = 8.781, p = .000*) compared to the rest of the students. This observation portrays one of the typical predicaments of learners: the complexity of the concepts of physics in their natural environment. These abstractions of physics, particularly electromagnetism, thermodynamics, and quantum mechanics, are challenging to students. It implies that creative ways of approaching the teaching endeavor are required to streamline such concepts, and maybe simulations and interactive tools can be used to visualize complex phenomena.

The lowest percentage of 1.2% of the students claimed that they did not like physics as an area of study, and the t-test (*t = 1.739, p = .083*) was not significant at *p = .05*. This goes to show that lack of interest in physics among the students is not a final determinant of the low performance of students in this sample. The other minority that happens not to be interested in the subject, however, might also need their attention, as it might not be able to continue its academic success due to the absence of interest. One of the solutions to overcome these attitudes and also see more students interested in physics could be more current studies with the use of physics or technology-based learning to make physics more applicable in the everyday life of students.

Although a small percentage of students (6.8 percent) claimed not to like their physics teacher, a t-test (*t = 4.262, p = .000*) was applied demonstrated that this variable is important. The role of the teacher-student relationship is very significant in establishing a good learning environment, and in case a student has developed a negative attitude towards the teacher, he/she will be influenced in a negative sense regarding contributing to learning and being motivated. This observation suggests the significance of the teacher-student relationship that may lead to a situation where teachers become more helpful and friendly to their students. This is the reason why the professional development program is not only centered on the details of the instruction strategies but also on interpersonal skills and classroom management tools to establish a closer connection with the students.

Among the notable findings of this research was the high number of mathematical computations related to the study of physics, and it was very important, as observed by the t-test ($t = 13.100$, $p = .000$). Physics is also among the subjects that may demand good mathematical skills, and in case the student is not able to master mathematics, then he or she will also not be able to master physics. This observation is an indication that there is a need to implement math support in the teaching of physics, like holding remedial classes or providing ICT equipment to provide a step-by-step guide to resolving problems. This obstacle may probably be reduced by ensuring the strengthening of the mathematical foundation of the students in order to make them more assured in solving physics problems.

The vast majority of students (29.6) showed that their school lacks proper resources to allow them to teach physics, and consequently, they cannot conduct experiments. The t-test ($t = 10.232$, $p = .000$) shows that it is an important factor statistically significant that leads to poor performance. Experiments in physical education are also very critical since they assist the learners in practicing and viewing what they are learning. The lack of resources like the laboratories, equipment, and materials is very limiting to the exposure of students to practical learning. Such observation means that the resource distribution in schools should be optimized immediately, if possible, in order to enable the conduction of viable experiments. The distance of having ICT resources introduced, like virtual labs, simulated work, etc., could also be exploited to enable the students to carry out the experiments even though the physical resources may not be available.

The percentage of students who said that a qualified physics instructor is not offered to them in school was only 2.8, and the t-test value ($t = 2.678, p = .008$) means that this percentage is not negligible. This reason is not mentioned by a high percentage of students, but the significance indicates that even in cases when teachers who are not qualified or not qualified enough are offered, it can play a crucial role in the performance of students. The tutors are expected to be well-trained and qualified to impart physics, especially since it is a very complex course. The professional development programs must be geared towards preparing the teachers with the knowledge content and pedagogical skills, and the application of the strategies of effective introduction of ICT in teaching physics.

The rates of those students who thought that physics is not presented in their activity in real life are also rather high (41.6%), and the t-test is also statistically non-significant ($t = 13.318, p = .000$). This is an indicator of a problematic situation during teaching physics. The students will not be as motivated or even interested in the subject without the capability to see how what they are learning has an application in their day-to-day life. As special care teachers, they ought to make efforts to put physics lessons into perspective by demonstrating to the students how physics is applied in all things touching on technology and transport, health, and athletics. The teachers can also enable the students to realize the relevance of the subject by showing how physics can be applied to the students and hence can enhance their performance.

A lesser proportion of students (8.4) indicated that they had re-evaluated their career goals, and it was no longer directly related to studying physics. This is a statistically significant variable, as the t-test ($t = 4.778, p = .000$) indicates. The interests that the students develop towards their career plans and goals are a major factor in the subject and performance choice in physics, and there could be a lack of motivation towards attaining excellence in the subject among students. Career guidance programs would be one of the solutions to this problem, as they would demonstrate to the students how physics can be relevant in a wide variety of occupations, not necessarily those more directly connected to physics, e.g., engineering or research. The percentage of students who agreed with the fact that the syllabus of physics is not taught is not very high (4.4), t-test ($t = 3.385, p = .001$), which is a statistically significant percentage. It is a low percentage, yet the fact is that there are some students who feel that the syllabus has not been attended to, so there is a need to be more vigilant over the implementation of the curriculum. The schools are supposed to see that the teachers are adhering to the syllabus and delivering all the requisite content on time. This once more leads to the point that it would need support structures where the teachers can properly plan their time and through which they can be competent working through the entire syllabus before the exams.

The t-test ($t = 12.670, p = .000$) used to describe the percentage of students who admitted to not studying effectively before their physics exams (39.2) depicted an incredibly strong point, which was that of performing poorly. This observation would imply that the learners can be ineffective learners or have poor exam preparation techniques in physics. The learning materials that are expected to be delivered by the schools to the students include revision manuals and previous examination papers, and the learners should be trained in the learning habit. The other individual that can be factored in is the teacher, who can administer regular quizzes and formative assessments to ensure that students have ample time to prepare to take their final test. As Table 15 indicates, failure of physics students in KCSE exams has a number of reasons, and some of them are instructional strategies and content complexity, among others, and resource availability and student motivation. The results indicate that some special efforts must be made to improve the internal (teacher-student relations and study habits) and external (resource shortage and curriculum coverage) factors.

4.11 Evaluation of the Findings

4.11.1 Introduction

The evaluation of the findings is critical in examining and interpreting the outputs of the study in relation to the objectives. The study aimed to analyse the factors that restrict the utilisation of technology in Physics teaching at secondary schools in Nairobi County, Kenya. The study was guided by the subsequent research objectives: 1) to assess the ICT resources available for physics instruction, 2) to identify the teaching methodologies that integrate ICT in physics education at the secondary level, 3) to examine the influence of physics instructors' attitudes on the integration of ICT in physics education, and finally, 4) to investigate the impact of physics students' attitudes on the usage of ICT in physics education.

The systematic literature review shows that the evolution of technology has greatly changed how education is transferred to learners. Kenya has tried to adopt the use of technology, especially in the telecommunication industry, manufacturing industry, E-commerce, E-banking, Health, Transport, and lately in the education sector to improve service delivery to potential customers (Gatembu, 2023). The process of ICT integration in education has been gradual and extremely slow compared to other sectors of the economy. Further to note, despite the government's efforts to equip schools with ICT resources, schools do not have adequate resources for instruction, a few teachers have not been retooled, and poor political goodwill to support the use of ICT in the pedagogy. The findings of the study are assessed to determine if they align with the existing literature on the effective utilisation of ICT resources for educational purposes. This chapter examines the implications of the results output for other referenced empirical investigations, aiming to identify any confirmations or discrepancies in the results. The study findings are evaluated systematically according to theme areas that correspond to the research topics that led to conducting the investigation.

4.11.2 Evaluation of the ICT resources available for physics instruction

The research was done to establish the ICT tools that could be employed to teach physics at the Nairobi schools in Kenya. A very high percentage of the interrogated secondary schools agreed to possessing ICT resources, including desktop computers, laptops, tablets, printers, and photocopiers, among others. These resources are, however, reported to be insufficient, and they are mostly utilized in the administration. This study tried to establish whether there are ICT resources that are used in teaching physics in secondary schools that exist today. Nevertheless, it is also clear that the available ICT resources are limited already, and they are only implemented in the administrative functions. The output results are comparable to those found by Jang et al. (2021), who explain that education is not being introduced in schools due to the lack of digital devices. Others that should be mentioned are that there are no ICT tools, such as the teleconferencing facilities, available in the secondary schools in Nairobi, or learning programs that are being developed in the Kenya Institute of Curriculum Development (KICD), which are key in teaching physics in such a way that students can pass physics exams.

The KICD was tasked by the government to digitize educational content and learning resources of all subjects and distribute them to schools for instruction purposes (KICD, 2017). The ICT resources provided by the government to schools are not adequate, and there is a need for the government to develop new ways of allocating financial resources to schools for the acquisition of more ICT resources. The schools sampled acquire ICT resources through direct purchase as opposed to procurement or donation, which are methods that could have been used to acquire more ICT resources on a large scale. Direct purchase is favourable only if the school is acquiring very few resources that are used for administrative functions only, and that is why the majority of the schools sampled have very few ICT resources. Procurement could have been the best method to use through qualified bidders if the schools had the financial resources to acquire adequate ICT resources.

For effective implementation of the new Competency-Based Curriculum as well as Competency-Based Assessment, there is a need for schools to leverage technology to improve the competencies of students, as explained by Ogada et al. (2023). The main goal of a Competency-Based Curriculum is to enhance the 21st-century skills among students, including digital literacy, critical thinking, effective communication and collaboration, problem-solving techniques, and citizenship, as outlined in the curriculum framework of KICD (2017). The findings point out that schools have inadequate ICT resources that are critical for the effective implementation of the Competency-Based Curriculum framework to equip students to acquire 21st-century skills.

The use of ICT resources in physics education is critical in developing the learners' interest in physics and future careers related to this field. The physics teachers are not able to use ICT resources during the instruction process, and there are no classroom virtual experiments or animations to motivate physics students to make observations and draw their own conclusions from experiments. For instance, when teaching the topic of X-rays, if schools have ICT resources, the physics teacher could demonstrate the production of X-rays and show the physics students how the rays can be used to treat cancerous cells in the human body through computer simulation. Physics students could be motivated to become doctors or nurses in the field of medicine if only they could establish a sense of what is taught in the classroom environment of learning. The availability of technology resources not only aids in the transfer of physics knowledge from the teacher to the student but also accelerates the learning and retention process. The use of ICT resources enables students to store, process, and share physics content using a variety of resources, like social media and YouTube channels.

According to Kimani (2021), the analysis of the literature has shown that the use of technology is more prominent among the young generation at 80% and there is a need for a paradigm shift in the teaching methodology to motivate Generation Z toward learning. According to UNESCO (2021), ICT resources provide access to unlimited educational content that can support teachers during the instructional process. The availability of ICT in secondary schools in Kenya has a great impact on promoting access and quality education (UNESCO, 2021). The results show that the majority of schools lack ICT resources despite the enormous benefits of using ICT in physics instruction. The school principals associated the inadequacy of ICT resources with budget constraints from the government and a lack of interest in using ICT resources by the education stakeholders. The poor technological infrastructure of schools in Nairobi is a major hindrance to its effective implementation in schools. The majority of schools lack dependable electrical power to run their ICT equipment, which has a significant impact on how ICT resources are used to teach physics.

4.11.3 ICT-integrated teaching methodologies used in teaching physics

The second objective of this study involved identifying teaching methodologies used by physics teachers in the instruction process. Physics is a subject that supports the development of any country through technological advancement, improved health sector, and industrialization Uwizeyimana, 2018). The findings of this investigation resonate with the findings of Wambua (2018), such that the subject has been stereotyped to be complex in terms of instruction since the students believe that it is very difficult, irrelevant, and very boring. The study results suggest that a substantial proportion of teachers employ lectures, demonstrations, discussions, and explanations as teaching approaches. The study by Dolighan and Owen (2021) established that the traditional methods of instruction could not help the students to comprehend physics content.

The problem remains a persistent problem affecting the performance of physics students even in the 21st century, since the methods of instruction do not cater to the individual differences of all learners in the classroom. For instance, the physics teacher might prefer to use the traditional lecture method of instruction without having a keen interest in knowing whether the students understand the concepts or not. The integration of technology in physics instruction was meant to improve the quality of learning by bringing the realia into the physics classroom and not leaving students with a deep understanding of the practical concepts of physics. Physics teachers need to diversify instructional methods to include simulations and animations of physics practicals.

For instance, linear motion was pointed out by physics students as one of the difficult topics of physics in which the physics teacher could simulate the motion of vehicles to calculate the distances and forces involved in causing the vehicle to move. The use of ICT in the physics classroom makes the lesson more interesting and motivates students to be more inquisitive in the process of knowledge acquisition. The simulation and animation of physics content make students visualize the information and be able to comprehend it.

The physics student needs to be allowed by their teacher to manipulate the ICT resources during experimentation to discover and explore new information through observation. Alharbi (2014) asserts that observation is a fundamental strategy that physics students can employ to enhance their learning. The physics instructor should guide the discovery of new knowledge, transforming into an intermediary of the learning process rather than the only possessor of knowledge. When physics students have time to discover their knowledge through research, they feel motivated and appreciate the subject as very important in constructing their career pathways. The qualitative data from the principals show that schools have inadequate ICT resources and therefore they are not in a position to conduct virtual experiments.

Physics is a practical subject, and therefore, conducting experiments is very important for physics students in understanding abstract concepts. According to Okono (2023), instructional methods have been observed to be the major hindrance to academic performance in schools, which is consistence with the findings of this study, such that physics teachers majorly use lecture methods for instruction purposes. The retooling of teachers should be done frequently by the Teachers Service Commission (TSC) due to the rapid changes in technology for instruction, such that when one technology becomes obsolete, the teachers need to adapt to another new technology.

The Kenyan Government implemented *the National ICT Policy on Education* (2006), which was reviewed in 2021 and aimed at the adoption and use of ICT resources in education. The purpose of the review on ICT in Education and Training policy (2021) is to enhance the acquisition of skills through an e-readiness learning environment and create more centers of excellence, as well as digital hubs for employment opportunities for youth. The ICT policy (2021) was to promote public-private partnerships for resource mobilization. The findings of this study established that a proportional number of schools do not have ICT infrastructure and are not aware of this ICT policy in education and training (2021). The government lacks financial resources for the implementation of the recommendations of the ICT policy, which could spur economic growth and digital transformation in education. The study findings align with the findings of the Centre for Mathematics, Science and Technology Education (CEMESTEA, 2019), which revealed that although most physics teachers have been trained on how to use ICT in instruction, however, they still predominantly rely on traditional instructional resources that do not effectively enhance learners' knowledge, skills, and attitudes.

To improve learning outcomes in the physics subject, there is a need to develop a learning strategy integrated with ICT that focuses on the needs of the students through intrinsic motivation to understand the instructional objectives (Bogusevchi et al., 2020). The traditional, conventional way of instruction does not motivate all physics students, and the results of the study show that, because of the lack of communication between the physics teacher and the students, relatively few students set high goals for themselves on national tests. The integration of ICT would bridge the gap between the physics teacher and students if well utilized in the learning process, since the students are not completely able to understand what the physics teacher is doing in the classroom. Bogusevchi et al. (2020) indicate that the use of ICT becomes a medium of instruction between the teacher and students in making abstract physics concepts easier for the physics students to understand.

The use of ICT in physics instruction is primarily focused on student-centred approaches as opposed to teacher-centred approaches that dictate the teacher as the sole proprietor of physics knowledge. Students-centred approaches to learning physics include problem-based learning, collaborative learning, the use of projects, inquiry-based learning, and experimental learning, which are very critical for students to develop positive attitudes toward learning. In the student-centred approach, the students can conduct physics practicals with minimal support from the teacher, and this makes them discover a lot of knowledge. Assen et al. (2018) noted that there is a need for a paradigm shift from the traditional, predominantly method of instruction to student-centred learning approaches, which is in line with the findings. The traditional learning methods involve pouring information into the minds of the learners without focusing on their interest in understanding. The findings of this study encourage physics teachers to focus on the interests of learners to achieve the lesson objective, and the technology should be used as a medium of instruction that bridges the gap between the teacher and the learners. The study of Ayere et al. (2010) confirmed that there is a significant improvement in the performance if teachers adopt technology in the instruction process. The research problem of this study indicated that the mean score of physics in national examinations has been declining in Nairobi County, and one of the factors attributed to this decline was the lack of diversified strategies for instruction by physics teachers. Ramma et al. (2018) narrated that the interest of students is stimulated by changes in stimuli during the instruction process, and therefore, if the physics teacher maintains only one method, as found out from this study, then they will not be attentive in the classroom. The study's findings revealed that a lack of hands-on experience is a significant obstacle for students to achieve high performance on national tests.

The sampled schools did not have an appropriate ICT infrastructure to offer the pupils a chance to participate in both the practical and virtual experiments. The findings of the provided research are consistent with the results of Kimani (2021) in discussing the factors that influence the introduction of ICT in scientific teaching in the primary schools of the Mola region. As it was noted, incorporation of ICT in the primary school scientific education was conditional on a number of factors that included in-service education and training opportunities for teachers, teacher attitudes, level of ICT proficiency among teachers, and ICT resources. Moreover, it was found that the schools were characterized by a general shortage of ICT resources. The administrative office had limited resources available and hence could not be used in ICT. It is not just the physics teachers who need to master the ICT skills, but also how they use the resources in the process of teaching.

The review of the literature for this study indicates that the learning environment is changing very fast, and the use of technology-integrated approaches is gaining momentum in the classroom environment. Physics teachers need to speed up the adoption of technology. The study reveals that teachers are open to incorporating ICT into their teaching and learning methods. However, they want guidance on how to create lesson plans that effectively utilise the selected ICT resources for instruction.

The physics teachers need to draw graphs and diagrams using computer software in physics topics like linear motion, waves, and sound, which students find very difficult, as established from this study, to enhance their understanding of abstract concepts. The use of ICT should satisfy the needs of the teachers and the students in the instruction process, especially students with multiple intelligences and special needs students. The Technology, Pedagogical and Content Knowledge (TPACK) model used in the literature review of this study clearly outlines how physics teachers should be able to integrate technology in physics instruction, such that technology should be infused into their components of learning (Koehler & Mishra, 2008).

4.11.4 Physics teachers' attitudes on the integration of ICT into physics education

The study intended to identify the physics teachers' attitude towards the integration of technology in physics training, utilizing variables assessing several components on a Likert scale. A considerable proportion of physics instructors felt that the school administration supports the use of ICT in teaching and learning, and so they were receptive to obtaining training on how to utilize ICT devices for teaching. Remarkably, the majority of the sampled physics teachers believed that the employment of ICT may encourage students to perform better and develop a deeper comprehension of the subject matter. In the literature study by Jonah and Ogundile (2021), it was noticed that independent criteria such as age, gender, training skills, availability of ICT resources, and instructors' experience are utilized to evaluate physics teachers' views on ICT integration in the classroom. The study results reveal that the physics instructors feel that ICT delivers interactive physics courses within the learning environment, yet they cannot be able to perform experiments utilizing computer simulations and animations. Subsequently, a significant proportion of physics teachers were in agreement that they could provide computer-based activities to learners during physics lessons, they could teach physics using PowerPoint presentations, they could assess students using computer software like Excel and customized analytical software, and they could prepare an ICT-integrated lesson plan if they were well-trained.

This study reveals that intrinsic factors that restrict the adoption of ICT in education include instructors' views, classroom procedures, and reluctance to modify educational methods. The attitude of teachers is crucial for ICT integration in education, and a positive attitude is essential. Teachers' negative attitudes can hinder the integration of ICT in education. Studies by Kihoza et al. (2017) and Ngeze (2017) found resentment among teachers against ICT usage. However, most physics instructors agree that ICT resources boost students' interest in learning and would want to incorporate them into their classes if provided with adequate resources and equipped with technical skills. Half of the teachers believe they can achieve lesson objectives when ICT is integrated into the teaching process, and a significant proportion feel good when presenting an ICT-integrated lesson using computer software like PowerPoint. This study is similar to a study by Bindu (2017) in the UAE, which found that a lack of skills and competencies was the biggest impediment to ICT adoption.

In Kenya, most physics teachers are eager to incorporate ICT into their pedagogies, but due to poor resources and lack of technical know-how, they choose conventional lecture delivery. The attitude of the physics teachers is cultivated via motivation, such that if the teachers are intrinsically driven, then they may employ a range of ICT resources to make the class more compelling and exciting, as opposed to the teachers who lack teaching resources. This study indicates that physics instructors have a good attitude toward the use of ICT in physics teaching; however, a lack of ICT resources and severe workload among the teachers are the problems preventing the integration of technology in the classroom. The majority of the physics instructors have a strong enthusiasm for the use of ICT in teaching physics, and they feel that they are properly educated with ICT skills they can utilize ICT in their lesson delivery. The study found that many problems, including lack of self-esteem, fear of utilizing technology, lack of confidence, and lack of technical skills, are important indicators of instructors having unfavourable attitudes towards ICT integration in schools.

4.11.5 Physics students' Perceptions impact the usage of ICT in physics education

The study also aimed to determine the impact of physics students' viewpoints on the incorporation of ICT in physics instruction. A significant proportion of physics students express a strong preference for the school administration to acquire more ICT equipment, such as computers and projectors, to enhance instructional activities. They strongly advocate for the integration of ICT resources in physics education, as they feel it enhances teaching and experimentation. Furthermore, they are certain that their understanding of physics concepts improves when taught with the use of ICT resources. A significant proportion of the physics students expressed a preference for physics lessons that use ICT resources such as computers and projectors. They hold the belief that interactive media facilitates a better understanding of physics subjects. Physics students have a favourable view of using ICT in physics education. However, the scarcity of ICT resources in schools and the absence of skilled professionals to manage and maintain ICT infrastructure are the primary obstacles to using ICT in the classroom. The physics students desired that the physics instructors use ICT in their instruction to independently acquire and investigate information with minimal guidance from the teacher.

The results of this investigation are consistent with the findings of Perdy et al. (2021) on "*Students' Perception of Physics Learning Interactions,"* which found perception is primarily a psychological process rather than solely a sensory one. It is shaped by multiple elements, including attention, stimulus characteristics, individual values and wants, and past experiences. The psychological variables of physics students significantly influence their perspective on the use of technology in the instructional process. Thus, physics students should have a more favourable attitude towards using technology in the classroom to enhance their teacher's enthusiasm to do the same. The fact that most students pursuing physics modules in the university have been using computer technology and the nature of technology is also a testimony that would support the recommendation that technology be used in the teaching and learning of physics at the tertiary level. The integration can bring more knowledge of abstract and complex physics among the students. The findings of the research reveal that the motivation of the physics teachers to use ICT in the learning process is enormous. This is what they, however, cannot do because they do not have access to the resources of ICT. The researcher further states that the students in the private schools are more optimistic about the impacts of using ICT, a fact that shows that they believe in the use of ICT.

It is also assumed that the more advanced students will learn more because of the use of ICT in the classroom. The same can be done regarding the ICT skills of teachers. Through the use of technology in training, physics tutors can prove to be of great help to their students, especially in ensuring they learn complex subjects with ease. According to the research findings, the use of technology in learning physics can result in students becoming undisciplined, and this is the ultimate concern of most teachers. To overcome this anxiety, physics teachers need to embark on the adoption of technology in their teaching process. The attitude that the students show concerning ICT use in teaching is good because they are more exposed to technical devices like mobiles and laptops, and frequently use them compared to their teachers, who lack the technological skills to use the same.

The thesis has been aware of the fact that the process of teaching physics with the help of ICT can lead to a sufficient level of perception of abstract issues and make the lesson more accurate and engaging. In addition to that, the achievement of ICT proficiency among the students can be coerced, where the students are in a position to operate and manipulate the ICT devices. Based on the study conducted by Alharbi (2014), which was utilized in "*The Use of ICT in Teaching in Secondary Schools in Kuwait*", it was found that male students were more successful in the application of e-learning models compared to female students. Besides this, the influence on the perception of the implementation of ICT was also more prone to the females, and the influence of the perception of the value of e-learning in decision-making on the adoption of ICT was also more prone to the males. Findings of this paper indicate that the introduction of ICT in teaching and learning physics at the high school level might provide some kind of aid to enable physics learners to learn to manipulate the abstract concepts in terms of experiment and demonstration. This will enable them to realize the practicality of the subject in their lives, and people will appreciate the subject.

4.11.6 Summary of Reporting and Result Trustworthiness

The reliability, credibility, and precision of data in the study was conducted on the factor influencing the usage of Information and Communication Technology (ICT) in teaching physics in secondary schools in Nairobi County, Kenya. The study was carried out to assess the availability and utilisation of ICT facilities, instructional ICT practices and the attitude of the instructor as well as the student` perspective towards the use of ICTs in teaching physics. It is important to note that study adopted a mixed method approach that involved collection of both qualitative and quantitative data were employed in the presentation of the results in tables, figures and charts. The study indicated that there are significant proportion of secondary schools that are not well equipped with ICT facilities like scanners, teleconferencing facilities, KICD-generated digital materials, or internal production of physics data that can be adopted to enhance the learning process. The ICT facilities, which are already in place in the schools, are mainly used on the administrative side as opposed to the teaching side.

The study's secondary aim was to ascertain the approaches for incorporating ICT into the instruction and acquisition of physics at the secondary school level in Nairobi County, Kenya. A significant percentage of physics educators employ Discussion, Explanation, Lecture, and Demonstration approaches to support the process of teaching and learning. The majority of the polled school administrators concurred with the physics teachers' claim that they employ both lecture and experimental methodologies in the instruction of physics. This study found that a minority of physics teachers utilize ICT resources to improve the education and learning of physics students. The limited use of ICT can be linked to a deficiency in training among physics teachers about the appropriate utilisation and operation of ICT devices, as well as a scarcity of ICT equipment in secondary schools in Kenya. The principals have noted that most secondary schools are facing a deficit of financial resources to obtain essential ICT resources for teaching and learning. In addition, the teachers need to undergo retooling to develop their knowledge and skills, which will ultimately lead to an improvement in the teaching and learning process.

Interestingly, the majority of the physics teachers agreed that the use of technology might serve as a source of inspiration for students, leading to improved performance and a more profound comprehension of the subject matter. The study confirmed that the use of technology is very crucial in the instruction and acquisition of physics knowledge since it facilitates the comprehension and understanding of abstract ideas for learners. Despite the majority of the physics teachers showing confidence in using ICT tools, a significant proportion of them strongly disagreed that there were some ICT tools, like projectors and physics software, that they could not effectively utilize in the classroom. They also thought that ICT offers interactive physics lectures in the learning environment; however, they are unable to perform experiments utilising computer simulations and animations. The majority of physics instructors expressed a strong consensus that the use of technological resources enhances students' engagement in learning, and they would like to include ICT in their physics lessons if well taught and provided with ICT equipment. It was noted that 50% of physics instructors are confident in their ability to accomplish class goals with the integration of technology in the instruction process. In addition, they experience satisfaction while delivering an ICT-integrated lesson using a PowerPoint presentation.

The attitude of the students is extremely critical in the successful implementation of ICT in the teaching and learning process of physics, as it helps in solving any challenges that the students have been facing. A large percentage of the student body of physics is a passionate advocate of the use of technologies in learning physics and experimentation. They feel that they are able to master the concepts of physics easily when it is taught using the ICT materials. In addition to this, they also like physics lessons that incorporate ICT, such as computers and projectors. Furthermore, they reckon that physics subjects can be learned using interactive media. Implementation of ICT in teaching and learning physics at the level of secondary level can provide substantial equipment to help the students in grasping the complex topics with the help of experiments and demonstrations. That will help individuals see the feasibility of the topic in their quotidian existence, which will make them value and acknowledge the issue.

The research study entailed the use of technology in physics learning concerning instructional procedure, instructional materials, teacher attitude, and learning perception. It was discovered that in Nairobi County in Kenya, a good percentage of the secondary schools in the county lack strong ICT resources like computers, laptops, photocopiers, printers, scanners, teleconferencing, and digitally resourceful schools, even though the schools with ICT resources are not effectively utilized to teach students. This observation conforms to the study conducted by Rashid and Yadav (2020), which determined that insufficiency of access to ICT resources in schools was the key factor making the implementation of ICT in education rather challenging. The findings of the Mwila (2018) study contradict the findings of this one because the same study revealed that the number of physics teachers who use lecture and discussion is large, and few apply discovery and explanation processes.

This has been caused by the lack of proper training on how to utilize the technology in teaching and learning, and poor ICT facilities. School principals have budgetary constraints in their quest to purchase ICT equipment to accommodate the instructors. The majority of the physics teachers believe that ICT enhances learning and creates interest amongst the students to learn physics. The attitude of the application of technology in the study of physics affects the interest and optimism amongst the students, and they can easily learn the concepts of physics when they are taught via the application of ICT tools, as they are already familiar with the digital world.

CHAPTER FIVE: IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

5.0 Introduction

According to Creswell (2017), the implication in research is "a *term that is used to mean the significance of the study and how it will influence the future of the research*". The gap was established through the literature of other related studies that had previously been studied, and the research findings were used as the basis of developing the gap-closing formulation. The study's implications are practical and would be directed towards closing the gap between the physics teachers and the learners in the context of ICT integration in physics instruction at secondary school level in Kenya. This thesis was a critical discourse of the constraints that influence the usage of technology in the teaching of physics at the senior school level within the Nairobi County.

The study was directed by the following key research objectives: 1) to evaluate the ICT resources available for physics instruction in Nairobi County secondary schools, 2) to identify the ICT-integrated physics teaching strategies used in secondary education, 3) to determine how physics instructors' attitudes impact the integration of ICT into physics education, and lastly 4) to determine how physics students' attitudes impact the usage of ICT in physics education. Research implications explain the consequences of research findings. Implications are evidence-based statements linking the literature review, the study findings, and underlying theories for future action. Implications have the purpose of discovering how the findings of the study matter to the literature review. The implications of the study are discussed based on technological implications, study findings, and the topic of the study. The implications of this study are presented per thematic area of each research question, and a conclusion was drawn.

5.1 Delimitations and Limitations of the Study

The methodology section employed mixed method research design and data collection methods included the questionnaires for collecting quantitative data and interview schedules for collecting qualitative data due to limited time and financial constraints. If the study had employed more qualitative methods that included longitudinal observation of more information-rich data could have been collected for analysis to determine the determinants constraining the use of ICT in physics education. Financial constraints and limited time for utilizing more exhaustive and comprehensive methods of data collection could have hindered the researcher from collecting rich data due to the diverse nature of the population involved in the country. The study was delimitated by collecting information from principals, Physics teachers and students; hence, more rigorous data is required for the entire Country to effectively understand determinants influencing the use of ICT in the Kenyan education system.

5.2 Ethical Considerations Issues

The study strictly adhered to ethical procedures and considerations to safeguard the welfare of the participants. Ensuring that the participants were adequately informed about the significance of the study and how their data would be carefully and securely handled was crucial in protecting their rights. The participants voluntarily signed the consent form that was attached to each research tool before responding to the tools. The tools for data collection were submitted to the UNICAF Research Ethics Committee (UREC) and were approved on **2nd May 2023**. The data collected was kept under lock and key to ensure the confidentiality of the data and was only used for the analysis of this study. The gatekeeper was signed by both the supervisor and the researcher and was strictly used to seek approval from the National Commission for Science, Technology & Innovation (NACOSTI) for data collection in Kenya. The license for conducting research in Kenya was issued by NACOSTI on **4th June 2023** under the license number: **NACOSTI/P/23/26352** and Reference Number**: 639871.** The license was only valid for one year, and therefore it expired on **4th June 2024.** The researcher briefed the participants, who were very instrumental in the data collection process, and the purpose of the briefing was to ensure that the data collected was reliable and valid. This chapter discusses the implications of the entire investigation as per the thematic areas of the study.

5.3 Thematic Sections of the Study

The overarching objective of this study was to determine the constraints influencing the effective implementation of ICT in physics instruction in Nairobi County within Kenya. The findings of this study were classified into four thematics areas that included availability and utilisation of ICT resources, usage of ICT integrated strategies in physics instructions and the attitude of physics teachers and students in relation to the usage of ICT in the physics classroom. The thematics areas are discussed in the subsequent section.

5.3.1 CT Resources for Physics instruction in schools

The study rigorously investigated the available ICT resources for physics instruction in secondary schools in Nairobi County, Kenya. The targeted secondary schools were located in informal settlements within Nairobi County. According to the Ministry of Education report (2013), the government had provided eleven (11) computers, one projector, and internet connectivity to secondary schools within Nairobi County. Therefore, from the intensive literature review, the researcher expected that the majority of the schools located within the city should have adequate ICT resources as compared to the schools located in rural settings. In addition, teachers working in urban schools should be ICT-compliant and have the technological know-how on how to implement ICT usage in education. The review of literature by Amuko et al. (2015) established that the majority of secondary schools within Nairobi were facing numerous challenges that included lack of ICT resources and lack of technical skills among the mathematics teachers in integrating technologies. Further, noting from the study by Kukali (2013) and Kurniawan (2014) that schools that had ICT tools for instruction purposes were acquired through donations from non-governmental organizations. Subsequently, this study also established that some schools that acquired ICT tools were also acquired mainly through donation as opposed to direct purchase or procurement.

The study further established that there is a digital divide in the use and integration of ICT in school management. The study by Awuor and Okono (2022) on systematic literature review of ICT integration in physics instruction noted that the integration of ICT in education to improve learning outcomes was meant to solve achievement problems and poor performance among the students. Therefore, the problems identified by Awuor and Okono (2022) needed to be addressed immediately to improve the learning outcomes and enhance the quality of learning. This study established that a proportional number of schools have inadequate ICT facilities that include scanners, digital content from the Kenya Institute of Curriculum Development (KICD), and teleconferencing facilities. The majority of the schools were using ICT mainly for administrative functions rather than for instruction purposes. Therefore, there is a need for the government to provide adequate ICT resources to schools for the effective implementation of physics education in the country. The inadequacy of ICT resources continues to derail academic performance in physics education, and the majority of physics students are getting demotivated towards the learning approach used by physics teachers that only focuses on a teacher-centred approach as further noted by the Ministry of Education (2022).

The incorporation of ICT resources that include desktop computers, laptops, projectors, educational software, and digital content in the instruction of physics education is very important in improving the learning outcomes of physics students. ICT resources are critical in enhancing 21st-century skills among students that include effective communication and collaboration, critical thinking, innovativeness, creativity, and digital literacy. The use of ICT resources simplifies abstract physics concepts in the classroom by making the content more interesting for the students to understand. The availability of ICT resources is very important in the effective implementation of the teachers' pedagogies.

The inadequacy of resources has a negative implication in the acquisition of learners' competencies that greatly affects the candidate's performance in a specific subject. This study established that the use of ICT resources in physics education is one of the major factors hindering the effective learner-centred approach and greatly demotivates students from selecting physics as one of their preferred science subjects in secondary education. The Ministry of Education needs to continue sourcing more financial resources to equip schools with ICT infrastructure that will enhance the development of 21st-century skills among learners.

5.3.2 ICT-integrated Strategies for Teaching Physics at the Secondary Level

The study sought to investigate ICT-integrated strategies that could be used to improve the quality of learning physics at the secondary school level. The review of the literature shows that the traditional methods are still dominating many physics classrooms. The majority of schools are dominated by teacher-centred approaches to learning as opposed to the expected learner-centred approach. The study by Mavu (2021) on ICT integration in secondary schools established that teaching using ICT improved the performance of the students, and this study is in coherence with Ademeyo (2010), who found that the performance of physics in the experimental group improved drastically than the control group that was taught with the traditional methods.

The literature on the use of digital resources indicated that inadequate ICT resources, lack of technological skills, and limited preparation time for developing an ICT-integrated lesson plan were the major factors affecting the effective implementation of technology education. The literature review agrees with the findings of the study that established that the majority of schools are limited in the use of ICT resources; therefore, they cannot use learner-centred approaches that include virtual experimentation, computer-based projects, and the use of interactive learning technologies.

The study established that the majority of physics teachers use lectures, demonstrations, discussions, and, to a large extent, explanations as methods of physics instruction at the secondary level. These methods need to be incorporated with technology to make the lessons more interesting and engaging for the physics students. The adaptation of virtual reality and augmented reality brings into the physics classroom a new horizon of learning in which learners are expected to interact with the content as opposed to passive learning as it is traditionally practiced.

The technology-based methods will positively impart knowledge of physics to the students and drastically change their attitude toward physics education. The physics teachers should be able to understand the psychological preparation of the students in terms of the classroom behaviour and type of physics content and select appropriate technology that can be used to achieve the objectives of the lesson. Sengul (2024) pointed out that the inclusion of technology in physics education improves the quality of learning and retention of the physics content, which is very instrumental in Bloom's taxonomy, as used to explain how learners perceive knowledge. The physics students can relate what has been taught in the classroom to what is happening in the surrounding environment, and technology is appropriately fused in the teaching and learning process. The findings on the ICT- integrated strategies were expected from the literature review since the majority of schools have inadequate ICT resources, as established from the first objective of the study. The few schools that were found with some ICT resources tried to adopt ICT resources like laptops and projectors for learning purposes, but a significant proportion of the schools used ICT resources for administrative functions only.

There is a need to retool teachers on the novel approaches to learning that could improve the learning outcomes of physics students. Since the students are now in the digital era, it will be significant for the teachers to learn new technology methods of teaching that are user-friendly and learner centred. The technology-based methods of teaching involve PowerPoint presentations of physics lessons, the use of virtual experiments and demonstration animations, and the simulation of physics content to make it more interactive and appealing to the physics students. This study advocates for technology-based methods of learning that require teachers to use ICT resources in the teaching of physics to make the abstract content easier. Virtual experiments shown using ICT resources could make students visualize how the real experiment is done without having the physical laboratories.

These findings are resonating with Awour and Okono's (2022) findings that leverage technology to enhance learner-centred approaches. Their paper proposed active learning by using technology to harmonize all the learning experiences for all the learners. The study by Ali et al. (2023) on the "*effect of ICT integration in secondary schools, physics achievement, and Reasoning skills"* was in coherence with this study, which establishes that technology-based methodology improves the quality of learning. It was noted that a significant number of secondary schools in Nairobi County are faced with financial constraints for acquiring ICT resources that are very important for physics instruction. The physics teachers surveyed agreed that the use of ICT in teaching motivates learners and makes abstract concepts easier for physics students to understand. The teachers noted that they can be able to prepare an ICT-integrated lesson plan and achieve lesson objectives if they are well retooled and their respective schools are provided with ICT resources that could be utilized for learning.

5.3.3 Impact of the Physics instructor's attitude on the integration of ICT in Physics Education

The study established that a considerable proportion of school administrators support the use of technology in the instruction process. Therefore, teachers are receptive to being retooled towards the use of technological devices for specific instructional purposes. The physics teachers believed that the use of ICT in physics education would make the physics students perform better and deeply understand the abstract content of physics. The analysis of qualitative data revealed that a significant proportion of physics students were in agreement with the teachers about the use of computer-based activities that could improve the quality of learning. The physics instructors also believe that if well trained and retooled, they can be able to adopt the use of analytical software to enhance their presentation of physics lessons.

The expectations of this study were somehow expected but not absolutely due to the study area being situated in the urban setting, especially in the capital city of Kenya, but the researcher was more interested in the schools in informal setting environments to establish if they have ICT resources and their tutors have a positive attitude towards the adoption of ICT in the education process as opposed to the traditional lecture method. Schools located in urban settings tend to have an advantage over schools located in rural settings due to improved physical infrastructure, diverse communities, and access to social amenities. Therefore, the study established that the majority of physics teachers have smartphones and occasionally use them to search for information relevant to their subject of specialization. Hence, access to ICT resources makes the minds of physics teachers positively adopt technology in teaching as opposed to their counterparts in rural settings. The conclusion of this study resonates with Otieno's (2023) findings, which concluded that ICT integration in education is not about the availability of ICT resources in schools, but the attitude of the teachers is also very important. Physics teachers need to engage positively by leveraging technology in education to adopt technology-based methodologies. Conversely, if the teachers have developed a negative attitude towards ICT integration, then they will not change their minds from traditional teaching approaches to ICT-integrated strategies of which the students are more interested in, especially in this 21st century.

It was noted that the majority of physics teachers believe that the use of ICT boosts students' learning, and they are willing to incorporate technology in their teaching methods, provided their schools have ICT resources. If the instructors are intrinsically motivated to use digital resources to improve the quality of education, then students will equally perform better in their national examinations. The physics teachers' factors, such as self-esteem, fear of new technologies, lack of confidence, and inadequacy of technological skills, need to be handled by relevant stakeholders for teachers to effectively embrace technology.

5.3.4 The Impact of Physics Students' Attitude on the Usage of ICT in Physics Education

The physics students' attitude is also very important for the adoption of technology in learning. When the attitude of the physics students is positive towards technology-oriented learning, then it becomes easier for the physics teachers to adopt technology-based methodologies during the instruction process. The students believe that if the physics teachers could adopt virtual experiments and demonstrations in situations where physical experiments cannot be conducted, it would be easier for them to follow the lessons keenly. The students could be given more time to interact with ICT resources as well as with the physics content for them to understand. The students thought that they would perform significantly better in national examinations as opposed to their current declining performance. The study established that physics students find topics like *Linear motion*, *Waves,* and sound very difficult for them to comprehend, but if the physics teachers could adopt animation and simulation of the abstract concepts of these topics, the students would be able to understand, as opposed to only learning theory.

The students support the utilisation of ICT resources by their physics teachers for better learning to take place in the classroom. For instance, the use of PowerPoint presentations could make them motivated and easily follow the lesson development on their own with minimal support from the physics teacher. Physical objects in linear motion could be visualized in three dimensions using computer simulation software so that students could identify the variables under measurement, including distance, displacement, force, and weight. This variable of linear motion is very difficult for the students to comprehend if just taught using lecture and dictation methods only (Song, 2024)). The attitude of physics students has a positive attitude towards the use of virtual reality and augmented reality learning, which enables them to visualize the reality of the practicability of experiments and reconnects them with their surrounding environment. The intrinsic motivation of using ICT in the process of learning could motivate students to pursue the subjects even after completion of the high school course.

The findings of students' attitudes toward the usage of digital resources are in agreement with the study of Adeyemo (2010), who established that the introduction of ICT makes learning physics more interesting for the students. These findings resonate with Atwa et al., (2018) conclusions that flipped learning had a positive attitude effect on the students' academic achievement. Flipped learning is technology-based learning that requires students to have more control over the materials, and instruction is shifted from face-to-face to individualized learning. It is an active learning that students support as the best methodology of instruction. Therefore, this study advocates for the learner-centred approaches in physics education as opposed to teacher-centred approaches to learning. If technology is fused into the teaching approaches, it will significantly change the attitude of physics teachers and students towards the acquisition of 21st-century skills. The declining mean performance in physics will drastically improve if ICT resources are well utilized in education by teachers at the secondary level in Kenya.

5.4 Recommendations for Application

5.4.1 Introduction

Recommendations are proposed solutions that the researcher puts out to the intended audience for resolving the problems that have been identified in the study. The researcher must provide precise measures to be implemented in the policy, practice, theory, or future research.

Research recommendations may include feasible and effective techniques that provide advice to academics on how to tackle the issues identified in the study. According to George (2023) on how "*How to Write Recommendations in Research: Examples & Tips"* it was noted that research recommendations are distinct from implications in that they provide concrete direction to decision-makers, while implications have a wider emphasis on the relevance and repercussions of research results. The essential elements of research recommendations include the establishment of the research question or purpose, the specification of research techniques, the delineation of data collection and analysis procedures, the presentation of findings and conclusions, the consideration of limits, and the proposal of avenues for further study.

The suggestions provided by East et al. (2005) are precise and explicit, backed by a clear justification of the study, and explicitly linked to potential future research. The purpose of the suggestions is to address the main discoveries identified throughout the process of collecting and analysing data. This study proposes necessary suggestions to bolster the researcher's case and guarantee that the study results are distinguished based on their own merits. The results of this research are seen as a first move towards using differentiated learning in physics education at the secondary school level. Potential topics have been identified that may be explored to address the challenge of resistance to adopting differentiated learning via the use of technology in physics education. The conclusion enhances the comprehension of the reasons for the lack of integration of technology in physics education among secondary-level physics instructors.

5.4.2 Recommendations per the Research Question

This section examines the recommendations per the research questions. The major goal of the study was to establish determinants constraining the use of ICT in the instructional process at secondary schools in Nairobi County, Kenya. The literature review indicates that the lack of ICT resources such as computers, projectors, scanners, teleconferencing facilities, and audio and video facilities hinder the effective implementation of ICT integration in education. Other factors that hinder the effective integration of ICT include a lack of technological skills among the teachers, the attitude of the teachers, the heavy workload among the teachers, and the high cost of acquiring the ICT resources. The recommendations will also be based on the education stakeholders involved in the implementation of educational policies on what needs to be done to expedite the adoption of ICT in science education. The following were the Research Questions (RQ) addressed in this study;

RQ 1: To evaluate the ICT resources available for physics instruction

The study established that the majority of secondary schools do not have adequate ICT resources for instruction purposes. It was noted that the few schools that had ICT resources were mainly used for administrative functions. Therefore, there is a need for the Government, through the Ministry of Education, to continue allocating financial resources to schools to acquire ICT resources for learning. The schools also need to improve on the ICT infrastructure, including connections of the schools to the national grid, use of alternative sources of power, connection to reliable sources of internet, construction of ICT rooms, provision of audio and video facilities, and teleconferencing facilities that could be used to improve the quality of education. This study focused on the secondary schools found in the informal settlements of Nairobi County, where the quality of education is still below the acceptable international standards of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The role of UNESCO is to advocate for "*peace and security by promoting international cooperation in education, sciences, culture, communication, and information*". Further to note is that the few schools that have ICT resources acquired them through donations by non-governmental organizations, while some schools have purchased the ICT tools for administrative functions only.

The review of the literature has indicated that the use of technological resources improves the instruction process and, therefore, the Kenyan government needs to continuously invest in the provision of ICT resources to schools (Kimani 2021). For Kenya to become a middle-income country with the required industry workforce, the use of ICT resources is essential in equipping the learners with the skills required for the job market. The use of ICT resources is majorly used in the telecommunication, business, and transport industries, and therefore, it is important to use the tools in the education field so that there is a linkage framework between training and industry. The inadequacy of ICT resources in schools is the major factor hindering its effective integration in education. The digitization of educational processes cannot be overemphasized since they act as catalysts to infuse 21st-century skills that include effective communication and collaboration, critical thinking, creativity, innovativeness, and digital literacy among the learners. For students to fit into the world's competitive market, digital literacy, along with other 21st-century skills, is very important. Therefore, the study recommends the need for the government prioritize the provision of ICT resources to schools to improve the quality of education.

The need for public-private partnerships is very important to consolidate financial resources that can be used for procuring ICT resources for learning. If the government can allocate a proportional percentage of the annual budget for the provision of ICT resources to schools, after a given period, all the schools will have the required ICT resources that improve the standards of education. The financial commitment of the government on allocation of resources to schools to purchase ICT resources each financial year is very important to ensure that each school in the country will have the required ICT resources for instruction purposes.

RQ2: To identify the ICT-integrated physics teaching methodologies used in secondary education

The study examines the ICT-integrated physics teaching methodologies that teachers can utilize for instructional purposes. The study established that the majority of the schools use lecture, discussion, and demonstration as the key methods of instruction. The integration of ICT in the lecturing of physics at the secondary school introduces new methods of instruction that include exploration and virtual experimentation. The use of virtual experimentation is to make the acquisition of physics skills captivating and motivate the physics students toward the content being taught. ICT tools introduce virtual learning that includes simulation and animation of physics concepts for the students to comprehend.

The physics students are given opportunities to interact with the content through the manipulation of ICT devices, and therefore, they can understand the content that is being taught. Physics topics like linear motion, which were among the physics topics that were mentioned to be very difficult, could easily be taught using a simulation using a computer and a projector for learners to comprehend the concepts of learner motion. The review of literature observed that the use of ICT resources makes the lessons interesting and engaging as opposed to the traditional methods of instruction that render the students' passive learners and the teacher the sole proprietor of information in the classroom (Asoma, 2018). The physics teachers indicated that they are ready to integrate ICT into the process of teaching, provided that they are given ICT resources to use. They also indicated that they could prepare an ICT-integrated lesson plan, provided they are retooled and given the necessary skills to have confidence in adopting technology.

The ICT-integrated lesson guides the teacher on how and where to use the ICT tool, whether in the introduction, lesson development, or the conclusion stage. The physics teachers were of the view that if they are well-trained or equipped, then they will be able to integrate technology into the instructional process and effectively prepare an ICT-integrated lesson plan that can guide the lesson delivery process. Therefore, the study recommends adequate training and retooling for all teachers on the usage of ICT tools in education. The Teachers Service

Commission (TSC) should continuously organize the retooling of teachers on the process of ICT integration in instruction to cultivate a culture of technology-based learning. The uses of ICT enhance virtual reality and augmented reality in the classroom to ensure that students can visualize physics concepts within the classroom. The retooling of the physics teachers could equip the teachers to adopt technology in the instructional process. The Ministry of Education should continuously allocate financial resources to the Teachers Service Commission to retool the teachers on the available ICT-integrated strategies for teaching and learning physics.

RQ 3: To determine how physics instructors' attitudes impact the integration of ICT into physics education

Regarding the attitude of physics teachers toward the use of ICT in education, the study established that a proportional number of physics teachers have a positive attitude toward including technology in the instruction process. The review of literature by Kimani (2021**)** indicates that the teacher's attitude greatly influences the adaptation of technology in the teaching process. When the teacher's attitude is positive towards the use of ICT tools, then they will find it easy to adopt technology, as compared to when they have a negative attitude, since they will not adopt the technology in the instruction process. The attitude of the teacher is influenced by factors such as gender, age, and professional qualification that determine how the teachers perceive the concept of ICT integration in education. It was observed that the physics teachers were not affected by their factors and therefore they were of the view that the use of technology in the teaching of physics would improve the quality of instruction. The correlation between physics content and technology must have been one of the motivating factors for the teachers to effectively adopt technology in the classroom.

The physics teachers indicated that they are willing to integrate ICT into their pedagogy process on the condition that they are adequately trained by the Teachers Service Commission and provided with ICT tools by the Ministry of Education. The benchmarking exercise organized at the school level will significantly boost the motivation of the teachers to integrate technology in teaching. The principals even indicated that they would be happy if the government could provide ICT tools to all the teachers to use for instruction purposes. The physics teachers believed that the use of digital devices improves the standards of learning, and there is a need for the government to move with speed to equip schools with the requisite skills on technology integration in education. The physics teachers were confident that they could achieve the lesson objectives if they integrated ICT resources into the learning process. The Teachers Service Commission needs to continuously sensitize the teachers on the aspects of integrating ICT in the instruction process.

RQ4: To determine how physics students' attitudes impact the usage of ICT in physics education

The attitude of the physics students is also very important in the digitization of the education process. The students like using digital devices for communication, hence it becomes easier for the teachers to adopt technology in the instructional process. The study established that the majority of physics students support the use of ICT resources like computers, projectors, and the internet to stimulate interest in learning. The majority of the students are eager to see their teachers adopt technology in the instruction process, as opposed to communication only. The students have been born in the digital age, and therefore, they highly appreciate the inclusion of technology as opposed to some of their teachers who might feel that the use of technology is insignificant and does not add value to learning. The majority of the students were even wondering why their physics teachers were not adopting technology for instruction purposes. This study recommends that the school administrators and teachers play a critical role in ICT usage in the education sector, and it is important for the teachers to accelerate the use of technology in the instruction process. The faster the rate of adaptation of ICT in the physics instruction process, the faster the rate of comprehension of physics concepts by the students. The use of ICT in physics instruction would change the negative attitude of some physics students that the subject is very difficult as discussed by Song (2024).

The adoption of ICT in the process of instruction enhances learner-centred approaches as opposed to teachers' teacher-centred approaches that assume that the learners are passive in the classroom. It is through content interaction by the physics students that motivates the learners to develop an interest in the process of acquiring physics content. The students interact with the physics content through the manipulation of ICT resources provided by the teacher for learners to explore the content and draw their own conclusions. The physics students were of the view that if technology is adopted in the classroom, it will enhance their understanding capabilities and make them perform better in national examinations. Therefore, the four factors (availability of ICT resources, ICT-integrated strategies, and attitude of the physics teachers and students) are intertwined such that if they are addressed by the educational stakeholders, then they improve the learning outcomes. Table 19 shows the implementation matrix of the recommendation of the study.

Table 19

Implementation Matrix for the Recommendations of the Study

S/No	**Activity**	**Action to be Taken**	**Responsible Education Stakeholder**
1	Provision of ICT Resources to schools	• Sourcing of financial resources • Procurement of ICT resources • Donation of ICT resources	-Ministry of Education -Ministry of ICT -Non-Governmental Organizations
2	Initiating ICT-Integrated Strategies	• Training and Retooling of the teacher	-Teachers Service Commission (TSC) -Teachers

S/No	Activity	Action to be Taken	Responsible Education Stakeholder
		• Benchmarking with other teachers • Sensitization programs on ICT integration in education	Principals or Administrators -Board of Management (BOM)
3	Enhancing Positive Attitude among the Teachers and Students	• Sensitization programs on ICT integration in education • Continuous retooling of teachers • Integrating ICT resources in the instruction process	-Teachers Service Commission (TSC) -Teachers -School Administrators

5.5 Recommendations for Future Research

5.5.1 Introduction

This section discusses the recommendations for future research emanating from the study findings in Chapter 4. The goals of the study were; 1) to evaluate the ICT resources available for physics instruction in Nairobi County secondary schools, 2) to identify the ICT-integrated physics teaching methodologies used in secondary education, 3) to determine how physics instructors' attitudes impact the integration of ICT into physics education, and lastly 4) to determine how physics students' attitudes impact the usage of ICT in physics education. The fundamental elements of study suggestions included the process of conceptualizing the research results and proposing potential avenues for further research. The objective of the recommendations in this research is to provide pragmatic and implementable recommendations derived from the study's results and direct future studies, and to facilitate the translation of research conclusions into practical implementation. The researcher has incorporated the pertinence of the suggestions into the study's aims and furnished pragmatic measures for execution. This chapter's suggestion starts with providing a concise summary of the study's main results. The recommendation's goal and its intended effect in the realm of education are clearly expressed.

5.5.2 Recommendation as per the Key Findings of the Study

The study established that a proportion of schools do not have adequate Information and Communication Technology (ICT) resources like scanners, teleconferencing facilities, digital content that is supposed to be distributed to schools from the Kenya Institute of Curriculum Development (KICD), or in-house developed physics content that could be used to improve learning outcomes. The study established that those schools that had few ICT resources were mainly used for administrative functions and not for classroom instruction. Based on this key finding, secondary schools do not have adequate ICT resources to be utilized during physics instruction. Therefore, there is a need for the government, through the Ministry of Education, to invest in the provision of ICT resources to secondary schools to improve the instruction process. The government needs to partner with the private sector to provide adequate ICT resources like computers, projectors, printers, internet connectivity services, and teleconferencing facilities equipped with both audio and video capabilities for live classroom lesson presentations. The recommendations of this study are consistent with the suggestions made by Ngavana et al., (2018) when investigating "*the Extent of School Management Support of ICT Tools Integration in Teaching and Learning of Kiswahili Language in Public Secondary Schools in Kenya"* stated that the Ministry of Education should provide computers to every school in Kenya and enforce the mandatory integration of ICT in the teaching and learning process.

The schools provided with the ICT resources need to have proper documentation of the ICT resources provided by either the government or the private sector. This recommendation also concisely resonates with the recommendations made by Gikandi et al. (2015) that proposed the need for the government to construct and furnish computer laboratories in schools, ensuring that they are accessible to all primary school students, rather than only limited to first-grade students. This will guarantee the participation of parents in the execution of the curriculum. It is essential to provide a reliable power supply to schools by connecting them to the country`s energy infrastructure. The government should provide appropriate financial resources to schools to cover their electrical expenses. Educational institutions should also allocate resources towards acquiring projector equipment to improve the quality of visual assistance during PowerPoint presentations during physics presentations. Furthermore, reliable internet connectivity is critical in supporting instructors in their efforts to locate relevant physics content on the internet.

Secondary schools should have access to WiFi to ensure that their devices are connected to sufficient Internet access for accessing learning resources. The connection to reliable internet will allow teachers to conduct online learning and enhance their pedagogical abilities. The schools need to have clear and precise regulations on how the ICT resources are utilized for instruction purposes, as well as guidelines governing the adaptation of ICT resources across all the learning areas. This study was limited to physics only, but there is a need for more studies to be done on different subjects to assess what factors are limiting the use of ICT in the instruction process. Song (2024) noted that there is a strong correlation between content physics and the use of ICT resources. Therefore, it is easier for the Physics teachers to adopt technology in the instruction process as compared to the teachers of other subjects. The study established that only a relatively small proportion of teachers are adopting the use of ICT resources in the instruction process, and therefore, there is a need for more rigorous research to determine why the percentage of physics teachers using ICT tools is extremely low. There is a need for the Ministry of Education to sensitize the teachers on the available ICT resources that can be utilized for instruction purposes.

Further on objective two, it was noted that a significant proportion of physics teachers use discussion, explanation, lecture, and demonstration strategies for instruction. Consequently, there is a need to diversify the methods of pedagogy to involve the use of ICT resources by physics teachers. The majority of the school principals interviewed agreed with the physics teachers that they use lecture and experimentation strategies in teaching physics. These methods are in line with the traditional teaching pedagogies. Furthermore, professional development programs must prioritise the instruction of educators in interactive and collaborative Information and Communication Technology (ICT) techniques, such as GeoGebra, to foster captivating and participatory learning encounters. By implementing these guidelines, a more efficient and captivating learning environment may be established, resulting in advantages for both students and teachers.

It was noted that a low proportion of physics teachers use ICT resources for the process of improving the learning outcomes of their physics students. This was associated with a lack of training among the physics teachers on how to manipulate and use ICT gadgets, as well as the inadequacy of the ICT devices in schools. The principals also reported that the majority of secondary schools are faced with constrain of financial resources for acquiring the requisite ICT resources for teaching, and further, the teachers need retooling to equip them with the requisite knowledge and skills to improve the learning outcomes of students. The results of this recommend the use of digital devices to enhance 21st-century skills like creativity and interaction between teachers and students. The study suggests that future research should prioritise examining the influence of specific factors, such as infrastructure and government support, school leadership and management, digital competencies of students and teachers, and the teaching approaches employed (e.g., blended, online, and hybrid learning, flipped classrooms, project-based learning, inquiry-based learning), on the effects of digital technologies in education. The study anticipates that future research will provide a comprehensive understanding of digital transformation in schools by further examining the effects and determinants that affect digital capability. Notably, the majority of the surveyed physics teachers agreed that the usage of ICT can inspire students to accomplish better and gain a deeper understanding of the subject matter. The study established that ICT usage has significant importance in the pedagogy of physics since it makes abstract concepts easier for learners to comprehend and understand. The attitude of the physics teachers is very important in the utilisation of the available technologies for learning physics. The study established that the majority of the sampled Physics teachers strongly disagreed that they could teach physics by only using ICT resources like computers, laptops, and projectors. They further believed that ICT provides interactive physics lessons within the learning environment, but they cannot be able to conduct experiments using computer simulations and animations.

The study recommendations agree with suggestions made by Namodi et al. (2015) suggested that policymakers should consider the practical use of ICT when designing teacher programs. In addition, while evaluating the effect of teacher characteristics on the usage of ICT in the classroom, teacher professional development needs to be aware of the direct influence of these factors, particularly the role of teacher motivation towards ICT. The majority of the physics teachers supported the use of ICT resources, increasing students' interest in learning, and they would prefer integrating ICT in teaching physics lessons if well-trained and equipped with the necessary ICT devices. Half of the physics teachers believe that they can better achieve lesson objectives when ICT is integrated into the instructional process. Further, they also feel good when presenting an ICT-integrated lesson using a PowerPoint presentation, and they agree that the use of ICT enhances the acquisition of physics skills.

The findings of this study are consistent with the recommendations made by Njiiri (2024) on "*Teacher-Related Factors Impacting Integration of Information and Communication Technology in Teaching in Public Secondary Schools in Naivasha Sub-County, Nakuru*

County, Kenya". Njiiri suggested that to enhance ICT literacy among teachers and incorporate it into instruction, the stakeholders should actively strengthen teacher training, targeting both male and female educators. This would enhance learners' attainment of specified objectives. The government should implement policies that will promote digital literacy, especially in terms of providing schools with the necessary infrastructure and ICT resources.

To address the issue of insufficient ICT equipment in classrooms, secondary school administrators should ensure the provision of suitable technology facilities. Consequently, both students and instructors need to have access to ICT equipment in schools to enhance their utilisation throughout the learning process. Schools should ensure that computer laboratories are properly equipped. Teacher Training Colleges (TTCs) and Universities should infuse technology in their education programs to ensure that instructors are adequately equipped and ready to use it in the classroom. To guarantee that graduates of teacher education programs are professionally competent, KICD shall establish and maintain a standardized ICT practical course curriculum that includes a single sit-in exam.

For effective adaptation of ICT in the teacher's pedagogy, the attitude of the students is very significant in addressing the challenges that they might be facing. The majority of the physics students significantly support the use of technology in conducting experiments. They believe that they can easily understand physics content if taught using ICT resources and enjoy the physics lessons taught using ICT resources like computers and projectors. Further, they also believe that interactive media makes physics content easy to understand.

The inclusion of ICT in physics instruction in education might provide valuable resources that could aid physics students in understanding abstract concepts through experimentation and demonstrations. This will let students see how the topic applies to their everyday lives, which will help them understand the subject better. There is a need for physics students to constantly engage the students and explicitly explain to them the purpose of doing physics as the foundation of all other technologies. Nevertheless, the study suggests that it is important for teachers to independently act and show their drive towards using the existing digital learning resources in order to improve the instructional experience, as well as their professional growth. An extensive examination of the notion of *ICT as a pedagogical tool* is required, focusing on the teacher's inclination, assurance, drive, emotions, cognition, conviction, and practical implementation via classroom observations, including a broader scope.

The Teachers Service Commission should continue organizing retooling sessions to equip teachers with the requisite ICT skills and pedagogical skills. The study by Birir et al. (2013) on the "*Influence of Teacher Training Practices on Utilisation of ICT in Teaching Activities in Public Secondary Schools in Nakuru East Sub-County, Kenya"* recommended that teachers must take personal steps to use digital learning resources to improve the learning outcomes and their professional growth. Therefore, this study recommends an extensive examination to explore the notion of *ICT as a pedagogical tool* by assessing instructors' inclination, assurance, drive, emotions, cognition, conviction, and their practical implementation via classroom observations, including a greater number of participants. Regarding this context, there is a need for more intensive studies to be carried out to investigate the attitude and perception of other secondary teachers of other subjects except physics on their views towards ICT integration in the instruction process. All the teachers need to be brought on board with ICT integration in the education process to improve efficiency in the teaching profession. The following were the key specific recommendations from this study;

a) Construction and renovation of the ICT infrastructure in schools. This involves possession of a good power backup system, possession of sufficient ICT technicians, and complete computer laboratories. The infrastructure investments play a crucial role in ensuring that ICT is put to good use and that productivity has increased.

b) Conduct wide professional development training for educators to enable ICT literacy and skills using the support of various technologies. The training analysis should focus on the areas of weakness raised in the study, like the level of mastery of data processing software and the capacity to make effective PowerPoint presentations. The ongoing training is also necessary, as it will help the teachers to apply ICT in the most effective mode to plan the process of teaching and create productivity.

c) Leadership Training—Complete an extensive leadership training process, which aims to lead the collaborative and transformational leadership skills of the school administrators with a view to inculcating the positive impression of the ICT usage in the teaching process. The dynamic leader must also advance the project of integrating ICT and create an atmosphere of innovativeness and collaboration in schools. Once the school principals and administrators can accommodate the use of ICT in the instructional process, then the likelihood of teachers of the school doing the same will exist, and these teachers will be able to use the same process in teaching the subjects they have.

d) Curriculum Revision—The Kenya Institute of Curriculum Development (KICD) will need to modify curriculum designs to incorporate ICT skills acquisition at every level of learning. ICT devices used in the teaching process will assist in the inclusion of the students, their ability to undergo a personalized learning experience, and the training of the students for the digital age.

e) Establish and sustain relationships and cooperation with the other relevant stakeholders, i.e., government agencies, the corporate sector, and community partners. The Ministry of Education in Kenya is supposed to involve the private sector in enhancing the ICT infrastructure in order to avail the resources, as well as in encouraging innovation in the education practice.

f) Install monitoring and evaluation systems to identify the effectiveness of the ICT integration activities. The Ministry of Education should also be in a position to track and assess the adoption of ICT in education by teachers at a given time. The frequent feedback by teachers, students, and other stakeholders will help in identifying what should be further improved and what can be improved in the ICT approaches to suit the needs of the public high schools. The Ministry of Education should propose a monitoring and evaluation matrix so that the integration of ICT in schools can be sufficiently monitored.

5.6 Conclusion of the Study

5.6.1 Introduction

This chapter explicitly discusses the summary and conclusions of the study based on the findings in Chapter four. The following objectives guided the study; 1) to evaluate the ICT resources available for physics instruction in Nairobi County secondary schools, 2) to identify the ICT-integrated physics teaching methodologies used in secondary education, 3) to determine how physics instructors' attitudes impact the integration of ICT into physics education, and lastly 4) to determine how physics students' attitudes impact the usage of ICT in physics education. The significance of this study was to help the education stakeholders, Physics instructors, and principals in formulating effective ways to use ICT in education to enhance learners' achievements. The findings of this study are important for students as they help to enhance their self-confidence and enthusiasm for physics education among the physics students, hence fostering the development of their 21st-century abilities that include effective communication and collaboration, creativity, innovativeness, and digital literacy.

The conclusion section of the research provides a concise overview of the overall results, deducing implications from the entire process about the discoveries or determinations made, as well as the consequences of those findings. The conclusion is intended to help the targeted audience of this study understand the importance of the study. Therefore, this conclusion is not only a recapitulation of the primary aspects of the investigation or a repetition of the study issue but rather a consolidation of the crucial discoveries of the study about the study objectives. Regarding the interpretation of the study findings, the researcher recognizes the personal and professional experience in the field of education might have shaped the insights on ICT integration in the physics instruction. It is important to note that such experiences enhanced contextual understanding of the research topic maintaining reflexivity to minimise potential bias by procedurally and ethically collecting relevant data for decision making. Data triangulations approaches were utilised to enhance transparency and accountability in data analysis procedures. Therefore, the conclusion drawn from the analysed data reflects the participants experiences and empirical evidence generated from the study. The conclusion section presents a summary of learning theories for the study approach, a summary of the investigation methodology, and key points of the results.

5.6.2 Summary of Learning Theories for the Research Approach

Though the study was well organized and based on the constructivist theory of learning, the other theories that apply to learning physics using information, communication, and technology (ICT) in the school environment were the cognitivism and behaviourism theories of learning. The mentioned theories were applied uniquely in the study as a means of comprehending the intended learning environment and ability to improve the learning outcomes through the application of ICT tools. The constructivist theory was applied in disseminating the explicit description of the use of technology in the learning process. According to Ghimire and Edwards (2024), the constructivists believe that learning is a process, and since each of the learners is a unique one, then whatever learners undergoes will dictate what they can make. The popularity of the concept of social constructivism is specific to the digital age and aimed at the younger generation of students. One of the most famous conceptual models in the sphere of educational technology and teacher training nowadays is the so-called Technological Pedagogical Content Knowledge, or TPACK model (Al-Adwan et al., 2025).

To make the available technology fit into the classroom setting, one had to have a good grasp of the curriculum of physics in the classroom, the instructional methods, and the technology that was readily available to the classroom setting. The behaviourist theory of study further suggests that the personal characteristics of the physics teacher, like age, sex, education, teaching experience, and ICT knowledge, among others, are relevant in the determination of factors that restrict the application of technology in the classroom and allow its application among the teachers. According to the research findings, teachers are supposed to understand the type and the availability of ICT resources to enable them to use them in delivering lessons to the learners. It is determined that computer science research and technology are correlated with the cognitive concept of the working memory, or short-term memory, and the long-term memory. Investigating a broad range of variables that play a small role in different groups of practices of incorporating technology in teaching, the study aims at exploring the teacher competence, student attitude, individual grades, class composition, and the environmental influence.

5.6.3 Summary of the Research Methodology

This thesis employed a mixed research approach, which consisted of the collection of qualitative and quantitative data regarding the physics learners, the teachers, and the school principals as key datasets. Enhancing the validity and dependability of the research findings required cross-referencing the data points from various sources, which was made possible by the data triangulation technique. The study adopted a descriptive study design to collect and systematically analyse data in order to effectively respond to the study questions. This study conceptualised how variables such as instructional methods, instructional resources, and teachers' and learners' attitudes greatly affect the use of technology in Physics instruction. The

ICT resources that were examined from the literature review included PowerPoint presentations, Word presentations, Data analysis software, Simulation/Animation, Educational Physics games, Video/Audio, Virtual and Augmented reality, and Graphic applications for learning physics. The study descriptively examines whether the physics teachers are using these resources in the instructional process.

It was noted that the use of technological devices in physics instruction greatly depends on the techno skills of the physics teacher. The study employed a descriptive research design for the process of identifying the factors that influence the process of integrating ICT in the teaching process, as well as the generation of characteristics that aid in decision-making. The factors were described, and inferential statistics were used to understand which factors are more prominent in limiting physics teachers not to using ICT in education. The researcher's primary focus was to provide a detailed description of the variables and analyse the current state of Kenyan schools concerning the integration of ICT in the educational environment. The descriptive analysis enabled the researcher to draw reliable conclusions based on numerical information collected from the questionnaires.

The prediction and decisions were drawn by constructing a statement between the independent and dependent variables as numerical variables. The operationalization of the research questions made it possible to analyze the quantitative data easily and discuss the qualitative data in terms of emerging themes in the research. The ethical considerations related to this study were voluntary consent, informed consent, anonymity, and secrecy of the data of the subjects. The researcher was expected to show the dignity of the participants and to deal with them effectively. The Unicaf Research Committee approved the study and a research permit license from NACOSTI. The study and data collection tools were explained to the participants. The SPSS 26.0 software was used to process the data and was analysed using descriptive and inferential statistics. The statistical information was shown in frequency tables and graphs. Themes obtained and the quantitative data were coded and transcribed and discussed using the qualitative data. Information and Communication Technology (ICT) has stood to revolutionize the teaching process, especially in regard to the industrialized countries.

Inappropriate teaching methods, insufficient teaching aids, and a lack of enough teachers of physics in the secondary schools in Kenya have also contributed to dismal performance in physics. The problems that deter the use of technology in teaching are 1) the lack of supply of physics laboratories and equipment, 2) the lack of effectiveness of pedagogical strategies, and 3) the lack of availability of trained physics professionals and the poor attitude toward physics that is reflected in the students and the teachers.

5.6.4 Summary of Findings from the discussion

The existence and use of ICT resources in educational institutions are of significance in determining the effectiveness of integrating technology into physics education. Of concern to note is that despite the government's efforts to provide technology resources, secondary schools in Kenya are reluctant to adopt technology in the instruction process. Due to the phenomenon of educational globalization and the ongoing changes in the teaching field, the utilisation of ICT in secondary schools is gaining significant growth in the world. For physics instructors to utilize ICT for teaching, it is necessary to employ positive persuasive techniques that foster favourable attitudes among the teachers. Developed countries have made substantial efforts in providing ICT resources to schools to improve the quality of learning as noted by Badmus (2026).

The sessional paper No. 1 of 2019 highlights the need to incorporate and obtain ICT tools, enhance skills and knowledge, efficiently manage ICT tools, and use digital information for classroom teaching. The Kenyan government is actively investing in ICT infrastructure, internet connection, capacity development, and digital content production. However, the integration of technology in physics instruction is progressing slowly, and that is why the study investigated the limiting variables of ICT use in education. The use of technology in the instruction and acquisition of physics seeks to enhance comprehension of abstract principles and expedite the transmission of information and competencies to students. The Kenyan government, through the Ministry of Education, has made significant investments in providing ICT tools to elementary and secondary schools to enhance the quality of education. Kenya's Vision 2030 seeks to convert the nation into a middle-income economy with industrialization, providing its population with a high standard of living. The Africa Agenda (2063) prioritizes the integration of Information and Communication Technology (ICT) in education as a means to attain high-quality educational benchmarks. The implementation of ICT integration in the education policy (2022) specifically emphasizes the need to enhance the skills and knowledge of teachers at all levels, as well as guaranteeing effective administration and management of ICT tools, to guarantee high-quality education.

The analysis of qualitative data reveals that physics topics like Linear motion, Waves, Magnetism, Optics, Newton’s law of motion, Current Electricity, Measurement, and Electrostatics were very abstract and difficult for the students to understand. It was noted that the physics teacher should be able to integrate ICT into the instruction process to enhance the understanding of physics content among the students. The pedagogies that involve the use of ICT promote the development of 21st-century skills among teachers worldwide and also infuse positive attitudes and perspectives in teachers. To align learners' skills with the demands of the modern era, the approach to physics education has seen a significant transformation. While certain secondary schools in Kenya may possess ICT tools, they are seldom used by teachers for educational purposes. The attitudes and perspectives of physics teachers directly impact their technology usage in physics instruction. The teachers of physics are very important in implementing the physics curriculum at the secondary level in Kenya. Therefore, physics teachers need continuous sensitization and training on ICT use in education to develop confidence and fully understand the importance of this new approach.

According to the study by the Ministry of Education (2019), the Kenyan school system's 8.4.4 curriculum suffers from a significant shortage of physics teachers. The scarcity of physics teachers in Kenya hinders the incorporation of ICT in the instruction and acquisition of physics at the secondary school level. The responsibilities and prerequisites of physics educators in secondary schools, together with factors connected to teaching, might hinder the incorporation of technology in the twenty-first century.

The study found that a significant proportion of schools lack sufficient ICT facilities, such as scanners, teleconferencing facilities, digital content from KICD, or internally developed physics content that could be utilized to enhance learning. Among the schools that do have some ICT facilities, they are primarily used for administrative purposes rather than for teaching. Similarly, the majority of school principals noted that the primary power source for running ICT equipment was electricity, while one-third of them reported using solar energy. A summary of the literature review established that there is a need for the government of Kenya to allocate more resources and partner with the private sector in the provision of ICT resources to schools for quality of instruction across the country to meet international standards.

The study findings resonate with Wambua and Nyakundi's (2024) conclusions on ICT integration in teaching mathematics, who found that PowerPoint presentations and interactive whiteboard materials were the most common methods. GeoGebra was used by only 51.4% of the respondents. Other methods included online examinations, online learning, and internet searches. A minority of teachers used technology interactively, with most relying on display-based methods. Students were not actively involved in selecting and using ICT resources, and internet access was not fully utilized for accessing mathematics content and interactive learning opportunities.

The methodologies for integrating ICT physics education established that a considerable proportion of physics instructors use discussion, explanation, lecture, and demonstration. These pedagogies are the recommended traditional approaches to learning physics, but there is a need for physics teachers to incorporate new ICT methodologies that include virtual experiments and demonstrations, simulations, and animations. The review of literature established that the use of interactive technologies in physics instruction provides new learning opportunities for physics teachers to ensure they use authentic learning practices that learners can be able to link with experiential learning, such that they can construct new knowledge. The majority of the school administrators surveyed agreed with the physics instructors' use of lecture and experimental methodologies in the teaching of physics. The survey found that only a small percentage of physics instructors use technological devices to enhance instruction.

The study conducted by Wambua and Nyakundi (2024) determined that while the respondents were well-acquainted with internet use, deficiencies were detected in areas such as ICT infrastructure and computer laboratories. The findings of this research on the utilisation of ICT resources and methodologies were in line with the results of the study done by Wambua and Nyakundi (2024). These observations emphasize the need to implement focused interventions to promote educators' ICT literacy and improve infrastructure to successfully optimize educational management. The review of the literature indicates that the performance in physics can be improved if ICT-integrated strategies are infused into the pedagogies of the instruction. It is worth noting that the lack of training among physics instructors in Kenya on how to control and utilise ICT gadgets, as well as the insufficiency of ICT devices in secondary schools, were the factors linked with inadequate use of ICT. The principals reported that a majority of secondary schools are experiencing a financial constraint in acquiring the necessary ICT resources for the implementation of the physics curriculum.

Additionally, the teachers require retooling to equip them with the requisite skills to enhance the standards of the instructional process for the country to achieve Vision 2030 and Sustainable Development Goal number 4 of equity and access to basic compulsory education. The conclusion drawn by Turgut and Aslan (2021) stated that several key issues that stood out in their study included the proficiency of instructors in both ICT and pedagogy; the ICT skills of students; insufficient technical resources and assistance; lack of teaching resources, the attitudes of principals, and the quality and accessibility of ICT training for teachers are the main factors contributing to the issue.

Most teachers of physics in this study thought that the use of ICT was feasible as a motivational tool among students to enhance performance in school and to have a better understanding of the material taught in the physics field. This study came up with a conclusion that Information and Communication Technology (ICT) can be used to improve the instruction of physics. This is because ICT helps in the process of learning and comprehending abstract concepts among the students. The attitude exhibited by physics teachers is mostly dependent on the ICT integration in teaching and learning physics. It was observed that the majority of the interviewed physics instructors did not in any way agree with the principle that they could teach physics using ICT devices like desktop computers and laptops, projectors, and physics content software. They also defined that learning is interactive with the use of ICT and cannot achieve virtual experiments in which computer simulation and animation are applied.

Most of the physics teachers indicated that they were mostly agreeing with the application of ICT tools to increase the interest of students in the classroom. They also established that they would like to have ICT in their physics classes as long as they are well-trained and with ICT gadgets. As it is disclosed in the results of the findings in the summary by Turan and Karabey (2023), the implementation of the interactive technologies led to the substantial improvement of the academic performance and motivation. Thus, the paper indicated that half of the physics teachers believe that they can achieve classroom goals when using ICT in the learning and teaching process. Moreover, they also experience satisfaction in the process of presenting a lesson, which includes the use of ICT in the form of a PowerPoint presentation. Mwaniki et al. (2024) have also discussed how interactive and student-centered introductions in teaching mathematics by the use of ICT can render the subject more exciting and enable able to formulate practical approaches to learning that would serve the maximum benefit of the learning outcomes, which can be applied to this research study as well. They were inspired by their physics teacher, their parents, and other family members in the same measure as they drew inspiration from many physics' students. One of the physics students, coded **PS34,** said that;

I do enjoy and understand several topics and also the application questions; it is only a few topics that I find difficult, but I am sure that with the help of my teacher, I am going to reach my target (A physics student).

From the excerpt of the student PS34, it is clear that the student enjoys and understands various physics topics and application questions, finding some challenging but confident in their ability to achieve their target with the help of their teacher. The student's attitude is important in incorporating ICT in the learning of physics since it helps overcome any obstacles that the teachers might encounter. A considerable majority of physics students strongly endorse the use of ICT resources for the instruction of physics and the execution of experiments. They are confident in their ability to comprehend physics concepts effortlessly when taught utilizing information and communication technology (ICT) devices.

Additionally, they get pleasure from physics lessons that use ICT tools such as computers and projectors. Further, they hold the belief that interactive media facilitates comprehension of physics subjects. Integrating ICT into physics education at the secondary school level may provide useful tools to help students comprehend complex topics via experiments and demonstrations. This will allow individuals to see the feasibility of the topic in their everyday lives, leading them to value and recognize the subject. The four factors that have been identified in this study include the *availability of ICT resources, ICT-integrated strategies*, *the attitude of the physics teachers, and the attitude of physics students*. These factors are very instrumental in the effective process of integrating ICT into physics education. These four factors form a transformative model that inhibits the effective implementation of ICT in the education process, which needs to be addressed by education stakeholders in Kenya.

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APPENDIX A

Principal`s Interview Schedule

Introduction

"This is a structured interview schedule for gathering information on the factors that limit the use of information and communication technology (ICT) in Nairobi County, Kenya, for teaching and learning physics. The information provided will be handled with utmost confidentiality. Do not write the name of the principal or school on the interview schedule. Please mark the appropriate boxes in the questions below with a tick.

Informed Consent

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss them. I have received satisfactory answers to all my questions, and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g., audio recordings, video recordings) for my participation in this study. I understand that my data will remain anonymous and confidential, unless stated otherwise".

I consent voluntarily to be a participant in this study. Yes ☐ No. ☐

Section A: Bio Data of the Participants.

What is the gender of the principal? Male ☐ Females ☐ Prefer not to mention ☐

Select the category of the school. Boys ☐ Girls ☐ Mixed ☐

3. Select the academic qualification of the school's principal.

Academic Qualifications	(Tick (√) appropriately)
Diploma	

Degree	
Masters	
PhD	

4. What are the teaching subjects (s) of the principal?

……………………………………………………………………………………………

5. How long have you been a principal of this school?

1 to 3 years ☐

4 to 6 years ☐

7 to 12 years ☐

More than 12 years ☐

Section B: The use of ICT Resources in the Teaching and Learning Process

6. a) Do you have an ICT room or a computer laboratory room?

Yes ☐ No ☐ Prefer not to mention ☐

b) If yes, are all the teachers in the school allowed to access and use the room with their students?

Yes ☐ No ☐

7. Which method(s) of teaching are used by your physics teachers in this school to teach students?

S/No	**Method of Teaching Physics**	**Tick (√) appropriately**
1.	Lecture and Demonstration	
2.	Discussion and Explanation	
3.	Collaborative and Critical thinking	
4.	Discovery and Exploration	
5.	Lecture and Experimentation	
6.	All the above	
7.	Any other (Specify)………………………………	

8. What is the ability of your physics teachers in this school to use ICT resources in the teaching and learning process?

S/No	**Ability to use ICT resources**	**Tick (√) appropriately**
1.	Very Poor	
2.	Poor	
3.	Acceptable	
4.	Good	
5.	Very Good	

9. a) Are students in this school aware of the method(s) used by the teachers to teach them Physics?

Yes ☐	No ☐

b) Specify if yes?

…………………………………………………………………………………………..

………………………………………………………………………………………….

…………………………………………………………………………………………..

9. How many computers do your school have for the teaching and learning purpose?

a. None	☐
b. Less than 5	☐
c. 5 - 20	☐
d. Above 20	☐

10. a) Do your school have other ICT resources that are used for teaching and learning process?

Yes ☐	No ☐	Prefer not to mention ☐

b) Specify if yes.

…………………………………………………………………………………………

………………………………………………………………………………………….

10. a) The ICT resources are in good condition to aid the teaching and learning in this school.

Yes ☐ No ☐

b) If yes to Q10a, how do you maintain your ICT resources?

…………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………

11. a) Was your school provided with educational software's from Kenya Institute of Curriculum Development (KICD) for teaching and learning of physics or other subjects?

Yes ☐ No ☐

b) If no to **Q11a**, does your school have plans to acquire them in future?

………………………………………………………………………………………

………………………………………………………………………………………

12. What is the source of electricity used to run ICT equipment's in your school?

S/No	Source (s) of Power	**Tick (√) appropriately**
1.	Natural Gas	
2.	Solar energy	
3.	coal	
4.	Wind Power	
5.	Hydropower	
6.	Nuclear energy	

The attitude of Teachers on the ICT use in teaching and learning of Physics

13. How do you feel about the attitude of the teachers towards the adoption of ICT in the teaching and learning of physics?

S/No	Attitude of Teachers on ICT use	Tick (√) appropriately
1.	Excellent	
2.	Above Average	
3.	Average	
4.	Below Average	
5.	Very poor	

14. a) In your own opinion do you believe that the use of ICT can positively improve knowledge acquisition process in your school?

Yes ☐ No ☐

b) If yes to Q14a, in which way(s) can the use of ICT improve knowledge acquisition process in your school?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….

Learners' Attitude on the use of ICT resources in Teaching and Learning of Physics.

15. What do you think about the students` attitude on the use of ICT in teaching Physics as one of the sciences?

S/No	Attitude of Students on ICT use	Tick (√) appropriately
1.	Very Good	
2.	Good	
3.	Fair	
4.	Poor	
5.	Very poor	

16. a) Are your students able to handle and use ICT equipment's?

Yes ☐ No ☐

b) If yes to **Q16a**, why do you think so?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………..

17. What would be your advice to the Ministry of Education as far as provision of ICT resources to schools is concerned?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………………..

Thank you for responding to this Interview to improve the quality of teaching and learning of physics.

APPENDIX B

Questionnaire for the Physics Teachers

Introduction

The sole purpose of this questionnaire is to gather information on the variables influencing the use of ICT resources in teaching physics. All provided information will be kept private and confidential. Do not write your name and the name of school on the questionnaire. Please mark the appropriate boxes in the questions below with a tick (√).

Informed Consent

"I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions, and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise".

I consent voluntarily to be a participant in this study Yes ☐ No ☐

Section A: Bio Data of the Participants.

1. Select your gender Male ☐ Female ☐ Prefer not to mention ☐

2. Select the category of your school?

Boys ☐ Girls ☐ Mixed ☐

3. Select your age bracket.

Less than 22 years ☐

22 - 29 years ☐

30 - 39 years ☐

40 – 59 years ☐

60 years and above ☐

4. Indicate your highest level of academic qualification?

Academic Qualifications	**(Tick (√) appropriately)**
Diploma	
Higher Diploma	
Degree	
Postgraduate Diploma Education	
Masters	
PhD	

5. Select your teaching subjects (Tick all that apply).

S/NO	**Teaching Subject(s)**	**(Tick appropriately)**
1	Mathematics	
2	Physics	
3	Chemistry	
4	Biology	
5	Computer science	
6	Other (specify)…………………….……	

6. What is your teaching experience in years?

less than 5 ☐

5 – 10 ☐

11 – 20 ☐

Above 20 ☐

7. How many boys and girls are in the current form three Physics class?

Boys ☐ Girls ☐ Total ☐

8. a) How many lessons do you have per week?

Less than 5 ☐

5 -12 ☐

13- 19 ☐

20 – 29 ☐

Above 29 lessons ☐

b) How many Physics teachers are you in this school?

No. of Physics Teachers	(Tick (√)Appropriately)
1	
2	
3	
4	
More than 5	

Section B: The use of Information Communication Technology (ICT) Resources in the process of Teaching and Learning

9. a) Do your school have ICT devices like computers, laptops, and pro[ ]rs?

Yes	☐	No	☐	Not prefer mention

b) How were the ICT devices acquired by school?

i) Donation ☐ ii) Procurement ☐ iii) Direct Purchase ☐

c) Did you receive any training on how to use ICT in the process of teaching and learning?

Yes ☐ No ☐

d) Do you use ICT in the process of teaching and learning of physics?

Yes ☐ No ☐

10. Using a tick (√) to indicate the method of teaching physics that is **Most commonly** used when teaching physics. Tick all that apply to your school.

S/No	**Method of Teaching Physics**	**Tick (√) appropriately**
1.	Lecture and Demonstration	
2.	Discussion and Explanation	
3.	Collaborative and Critical thinking	
4.	Discovery and Exploration	
5.	Lecture and Experimentation	
6.	All the above	

S/No	Method of Teaching Physics	Tick (√) appropriately
7.	Any other………………………………	

11. Using a **tick (√)** select the available ICT resources in the school that you use in the teaching and learning of physics. If you use none of them, select None of the above

S/No	ICT Resources	Tick (√) appropriately
1.	Computers and Laptops/Tablets	
2.	Projector	
3.	Printer	
4.	Photocopier	
5.	Scanners	
6.	Internet connectivity	
7.	An interrupted Power supply	
8.	Mobile phones	
9.	Computer room/ICT room	
10.	Teleconferencing facilities	
11.	Storage media like Diskettes, CD-ROM, DVD, Flash Disks, Hard Disks	
12.	Physics educational software like SimPHY, MATLAB	
13.	Digital content from KICD	
14.	Interactive white board	
15.	Digital camera or Camcorders	
16.	None of the Above	

12. For each of the following statements, in your own opinion about the use of ICT resources, indicate using a tick **(√)** the physics strategies used in your school for teaching. The levels are **SD - Strongly Disagree, D- Disagree, U- Un decided, A- Agree and SA - Strongly Agree**.

S/NO	Statement	SD	D	U	A	SA
1	I teach physics using ICT resources like computer/laptop and projector					
2.	ICT provides interactive physics lessons					
3.	I normally provide computer-based activities to learners during my physics lesson					
4.	I can teach physics using PowerPoint applications					
5.	I can provide hands on demonstration to my physics students					
6.	I always use the internet effectively to download and upload physics content					
7.	I can assess students using computers software like excel and customized analytical softwares					
8.	I can conduct experiments and demonstrations using computer simulations and animations					
9.	I like teaching physics using technology devices					
10.	I can prepare an ICT integrated lesson plan					

13. The following statements relate to the attitude of teachers towards the use of technology. Using a **tick (√)** rate the statements depending on your own perception.

S/No	**Statement**	**Very true**	**True**	**Somehow true**	**Neutral**	**Somehow untrue**	**Untrue**	**Very untrue**
1.	The administration supports ICT use in the school							
2.	I am willing to be trained on how to use ICT to teach							
3.	ICT can provide array of teaching methods							
4.	I believe that the use of ICT can motivate learners							
5.	I can manage learners' discipline when using ICT resources							
6.	ICT can make physics abstract concepts easier for learners to understand							
7.	I do not like teaching Physics using ICT							
8.	The use of ICT has less importance to the learning of physics							
9.	The use of ICT in teaching physics is a waste of time							
10.	None of the above (Specify)………. ….							

14. What is the **major** problem(s) faced by physics teachers when using ICT in the teaching and learning of physics in this school?

S/No	**Problem**	**Tick (√) appropriately**
1	Lack of constant power supply	
2	Lack of ICT devices	
3	Lack of capacity among the physics teachers	
4	Lack of digital content	
5	Work overload by the teachers	
6	The use of ICT in the teaching process is viewed negatively	
7	Lack of expertise in using ICT for lesson delivery	
8	Any other (specify) …………………………………	

15. If you have ICT devices, how do you maintain them in your school?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………

16. a) Is the time allotted on the schedule for an integrated physics lesson's teaching and learning sufficient?

Yes ☐ No ☐ Prefer not to mention ☐

b) If **No** to **Q16a**, state the reason you think so……………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

17. The following statements relate to the attitude of teachers towards the use of technology. Using a **tick (√)** rate the statements depending on your own opinion. The levels are arranged from **SD - Strongly Disagree, D- Disagree, U- Un decided, A- Agree and SA - Strongly Agree.**

S/No	Statement	SD	D	U	A	SA
1.	The use of ICT motivates students					
2	The use of ICT resources increases students' interest in learning					
3.	I like integrating ICT in physics lesson					
4.	I normally prepare ICT integrated lessons					
5.	I believe in achieving lesson objectives when ICT is used to aid teaching					
6.	I feel good when presenting an ICT integrated lesson on a PowerPoint					
7.	I enjoy class discussion during the ICT integrated lesson delivery					
8.	My love for ICT use in teaching Physics is amazing					
9.	The use of ICT supports learning of physics					
10.	I like organizing ICT tools for classroom teaching					

18. In your own opinion as a physics teacher in this school, what do you think is the learner's attitude towards using ICT in teaching physics?

S/No	Statement	SD	D	U	A	SA
1.	The learners enjoy the ICT integrated lessons					
2	The learners actively participate in the learning process					
3.	Learners maintain discipline during the delivery of an ICT integrated lesson					
4.	Learners can easily manipulate and use ICT tools for learning					
5.	The use of ICT increases learner's concentration span to the lesson.					

Thank you for your precious time in participating in this study to improve the teaching and learning of physics in Kenya.

APPENDIX C

Physics Students Questionnaire

Introduction

This is a questionnaire and not an examination. The questionnaire seeks to learn more about your opinions regarding the use of Information and Communication Technology (ICT) in physics learning. The knowledge provided here will help to improve physics teaching for the students in Kenya. Your responses will be kept completely confidential. Please indicate accordingly where necessary using **a tick (√)**.

Informed Consent

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions, and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. ☐

I consent voluntarily to be a participant in this study Yes ☐ No

Section A: Bio Data of the Participants.

1. Select your gender Male ☐ Female ☐ Prefer not to mention ☐

2. Select the category of your school?

   Boys ☐ Girls ☐ Mixed ☐

3. What is the number of boys and girls in the current form three Physics class?

Boys ☐ Girls ☐ Total ☐

4. Select the number of physics teachers in your school.

No. of Physics Teachers	**(Tick (√) Appropriately)**
1	
2	
3	
4	
More than 5	

5. What do you plan to be when you complete school?

S/No.	**Career**	**(Tick (√) Appropriately)**
1	A Physics Teacher/Lecturer	
2	An Engineer	
3	A Doctor/Nurse	
4	A Pilot	
5	A Forensic Scientist	
6	A Computer Scientist	
7	A Meteorologist	
8	A Researcher	
9	An Artist	
10	Any other (Specify)…………..............	

6. Name at least **three (3)** physics topics that you find to be more difficult in understanding and can be made easier if technology is used in teaching them.

   i)…………………………………………………………………………………

   ii)………………………………………………………………………………….

   iii)………………………………………………………………………………….

7. a) What is your target grade in **KCSE** Physics examinations?

S/No	**Target Grade in KCSE**	**(Tick (√) Appropriately)**
1	A	
2	A-	
3	B+	
4	B	
5	B-	
6	C+	
7	C	
8	C-	
9	D+	
10	D	
11	D-	
12	E	

b) What motivated you to set the above grade target?

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………….

Section B: The use of Information Communication Technology (ICT) Resource in Teaching and Learning of Physics

8. a) Do your physics teachers use ICT devices like computers, laptops, and projectors in teaching physics?

Yes	☐	No	☐	Prefer not to mention	☐

b) Do you have skills on how to use a computer or a laptop for the learning purposes?

Yes ☐ No ☐

9. Using a **tick (√)** select the available ICT resources in your school that are used by the physics teachers to teach physics. If they use none, select None of the above.

S/No	ICT Resources	Tick (√) Appropriately
1.	Computers and Laptops/Tablets	
2.	Projector	
3.	Printer	
4.	Photocopier	
5.	Scanners	
6.	Internet connectivity	
7.	An interrupted Power supply	
8.	Mobile phones	
9.	Computer room	
10.	Teleconferencing room(s)	
11.	Storage media like Diskettes, CD-ROM, DVD,	

	Flash Disks, Hard Disks	
12.	Physics educational software like SimPHY, MATLAB	
13.	Digital content from KICD	
14.	Interactive white board	
15.	Digital camera or Camcorders	
16.	None of the Above	

10. In your own opinion, what is you're feeling about learning by using ICT resources. Using a **tick (√)** indicate your agreement or disagreement with the following statements. The levels are **SD - Strongly Disagree, D- Disagree, N-Neutral, A- Agree and SA - Strongly Agree.**

S/No	**Statement**	**SA**	**A**	**N**	**D**	**SD**
1.	I enjoy the physics lesson taught using ICT resources like computers and projectors					
2.	Our physics teachers like using ICT resources					
3.	Interactive media makes physics content easy to understand					
4.	I can understand physics content if taught using ICT resources					
5.	I support the use of ICT resources in teaching physics and conducting experiments					
6.	The use of ICT devices does not make me indiscipline					

S/No	Statement	SA	A	N	D	SD
7	I want the school administration to buy more ICT resources like computers and projectors					

11. Are you motivated by your physics teacher during the teaching and learning process?

Yes ☐ No ☐ Prefer not to mention ☐

12. What makes you **NOT** perform well in physics examinations. Select all reasons that apply to your case. If these reasons don't apply to you select None of the above".

S/No	Reason	Yes	No
1.	The physics teachers use very difficult method to teach		
2.	The physics content is very difficult to understand		
3.	I do not like the physics subject		
4.	I do not like the physics teacher		
5.	The subject has a lot of mathematical calculations		
6.	The school does not have enough resources for teaching physics hence no experiments are done		
7.	We do not have a qualified physics teacher		
8.	Lack of application of the subject to my daily life activities		
9.	I have changed my career ambitions, and it is not related to physics		
10.	The physics syllabus has not been taught		
11.	I normally don't prepare for physics examinations		

S/No	Reason	Yes	No
12.	None of the above (Specify)……………………………………		

13. Suggest some of the recommendations that can be put in place to encourage physics teachers to use ICT in teaching and learning of physics.

    i) ………………………………………………………………………………………

Thank you for your time in participating in this study.

APPENDIX D

UNICAF Recommendation Letter

UNICAF UNIVERSITY

23rd May, 2023

To Whom It May Concern

This letter serves as confirmation that Kubai Edwin with student ID number R1806D5512511 is currently enrolled in the Doctorate of Education (EdD) programme of Unicaf University in Zambia.

The student is currently undertaking research for the Dissertation, on the below topic:

'*Factors Limiting the Use of ICT in Physics Instruction in Public Secondary Schools in Nairobi County, Kenya'.*

If you require any additional information or clarification please do not hesitate to contact us in the first instance.

Best regards,

Ms. Selia Masoura

Registrar

Unicaf University:
Plot 20842, Off Alick Nkhata Road, Longacres, Lusaka, Zambia
Telephone: +260 211250522 **Email:** info@zambia.unicaf.org
www.unicafuniversity.ac.zm www.unicafuniversity.com

APPENDIX E

UNICAF University Research Ethics Committee

UREC Decision, Version 2.0

Unicaf University Research Ethics Committee Decision

Student's Name: Kubai

Edwin Student's ID #:

R1806D5512511

Supervisor's Name: Dr Alaa Allouch

Program of Study: UU-EDUD-900-3-ZM Offer ID

/Group ID: O55869G57282

Dissertation Stage: DS3

Research Project Title:

FACTORS LIMITING THE USE OF ICT IN PHYSICS INSTRUCTION IN PUBLIC SECONDARY SCHOOLS IN NAIROBI COUNTY, KENYA

Comments: No comments.

Decision*: Approved without revision or comments.

Date: 02 May 2023

*Provisional approval provided at the Dissertation Stage 1, whereas the final approval is provided at the Dissertation stage 3. The student is allowed to proceed to data collection following the final approval.

APPENDIX F

NACOSTI Research License

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

REPUBLIC OF KENYA

Ref No: **639871**

Date of Issue: **04/June/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Edwin Anyonyi Kubai of UNICAF, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: FACTORS LIMITING THE USE OF ICT IN PHYSICS INSTRUCTION IN PUBLIC SECONDARY SCHOOLS IN NAIROBI COUNTY, KENYA. for the period ending :
04/June/2024.

License No: **NACOSTI/P/23/26352**

639871

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 G

UNICAF University Research Ethics Application Form

UNICAF UNIVERSITY RESEARCH ETHICS APPLICATION FORM DOCTORAL STUDIES	UREC USE ONLY: Application No: Date Received:

Student's Name: EDWIN ANYONYI KUBAI

Student's E-mail Address: kubaiedwin@yahoo.com

Student's ID #: R1806D5512511

Supervisor's Name: Alaa Allouch

University Campus: Unicaf University Zambia (UUZ)

Program of Study: UUM: EdD - Doctorate of Education

Research Project Title: Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya

1. **Please state the timelines involved in the proposed research project:**

Estimated Start Date: 01-Feb-2023 Estimated End Date: 1-Dec-2023

2. **External Research Funding (if applicable):**

2.a. Do you have any external funding for your research?

☐ YES ☑ NO

If YES, please answer questions **2b** and **2c**.

2.b. List any external (third party) sources of funding you plan to utilise for your project. You need to include full details on the source of funds (e.g. state, private or individual sponsor), any prior / existing or future relationships between the funding body / sponsor and any of the principal investigator(s) or co-investigator(s) or student researcher(s), status and timeline of the application and any conditions attached.

N/A

2.c. If there are any perceived ethical issues or potential conflicts of interest arising from applying or and receiving external funding for the proposed research then these need to be fully disclosed below and also further elaborated on, in the relevant sections on ethical considerations later on in this form.

N/A

3. The research project

3.a. Project Summary:

In this section fully describe the purpose and underlying rationale for the proposed research project. Ensure that you pose the research questions to be examined, state the hypotheses, and discuss the expected results of your research and their potential.

It is important in your description to use plain language so it can be understood by all members of the UREC, especially those who are not necessarily experts in the particular discipline. To that effect ensure that you fully explain / define any technical terms or discipline-specific terminology (use the space provided in the box).

The main purpose of this study is to investigate Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya. The Kenyan government has invested in the provision of ICT devices to schools to promote 21st century skills of digital literacy. Physics is one of the science subjects taught and examined at the secondary school level with very few students selecting the subject in form three. The deteriorating number of learners interested in selecting physics at secondary school level and declining achievement performance among the physics students is a factor of concern to the education stakeholders. The government of Kenya has allocated billions of shillings to the Ministry of education to transform the quality of education to meet the international standards as envisaged by UNSECO (2020) declarations of being a basic human right. ICT tools like computers, laptops, tablets, projectors, and Internet connectivity services ensure that teachers and learners have access technology so as to improve classroom instruction. Teachers have been retooled on how to effectively use ICT but majority of the teachers are reluctant to embrace technology in the classroom. This study investigates why the physics teachers in public secondary schools in Kenya are not utilizing ICT related tools in helping learners to acquire the physics knowledge and skills. The research objectives are to validate the actual status of ICT tools in the secondary schools that were supplied with ICT tools by the government, identify the teaching and learning strategies used by the physics teachers, and examine the attitude of the physics that determines whether the physics teachers are willing to sue ICT tools or not. The findings of this study would be significant in informing the Ministry of Education on the actual status of the ICT integration in the teaching of physics so as to inform policy intervention.

3.b. Significance of the Proposed Research Study and Potential Benefits:

Outline the potential significance and/or benefits of the research (use the space provided in the box).

The main purpose of the study is to investigate Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya. The target area of inquiry is Nairobi County which is the capital city of Kenya. The study is based on the assumption that since the target area is in an urban setting, it is assumed that the majority secondary schools within this setting are equipped with ICT resources and have ICT trained teachers who have skills on how to effectively integrate ICT in the teaching and learning process.

The government of Kenya through the Ministry of Education has continually invested in the process of capacity building of the teachers and provision of ICT resources to schools in order to enhance digital literacy component among the learners. The findings of this study are expected to help education stakeholders; physics teachers in designing appropriate ICT integrated strategies that will help to improve learners' performance especially in the physics subject. Further, the findings of the study would be significant in informing the Ministry of Education on the actual status of the ICT integration in the Country so as to inform policy intervention.

4. Project execution:

4.a. The following study is an:

- ☐ experimental study (primary research)
- ☐ desktop study (secondary research)
- ☑ desktop study using existing databases involving information of human/animal subjects
- ☐ Other

If you have chosen 'Other' please Explain:

N/A

4.b. Methods. The following study will involve the use of:

Method	**Materials / Tools**
Qualitative:	☑ Face to Face Interviews
	☑ Phone Interviews
	☐ Face to Face Focus Groups
	☐ Online Focus Groups
	☐ Other *
Quantitative:	☑ Face to Face Questionnaires
	☑ Online Questionnaires
	☐ Experiments
	☐ Tests
	☐ Other *

*If you have chosen 'Other' please Explain:

N/A

5. **Participants:**

5 a. Does the Project involve the recruitment and participation of additional persons other than the researcher(s) themselves?

☐ YES **If YES, please complete all following sections.**

☑ NO **If NO, please directly proceed to Question 7.**

5 b. Relevant Details of the Participants of the Proposed Research

State the number of participants you plan to recruit, and explain in the box below how the total number was calculated.

Number of participants: 305

The target population is 120 public secondary schools with 276 physics teachers and 3,200 form three students within Nairobi County, Kenya. Simple random sampling will be used to identify 30 Physics teachers and 250 form three students. Purposive sampling would be used to select 25 principals making the total sample to be 305.

Describe important characteristics such as: demographics (e.g. age, gender, location, affiliation, level of fitness, intellectual ability etc). It is also important that you specify any inclusion and exclusion criteria that will be applied (e.g. eligibility criteria for participants).

Age range From 17 To 60

Gender

- ☑ Female
- ☑ Male

Eligibility Criteria:

- Inclusion criteria

1. The principals of the 25 sampled secondary schools would participle in the study.
2. The physics teachers would participate
3. The form three physics student would participate in the study

- Exclusion criteria

1. The principals, physics teachers and students must be in school during the study
2. The sample that participated in the pilot study would not participate in the main study.

Disabilities

The participants with disabilities who have been integrated in the regular sampled secondary schools would be allowed to participate in the study.

Other relevant information (use the space provided in the box):

N/A

5 c. Participation & Research setting:

Clearly describe which group of participants is completing/participating in the material(s)/ tool(s) described in 5b above (use the space provided in the box).

The study would be conducted in a school learning environment within Nairobi County, Kenya. The participants of the study would include the school principals, physics teachers, and the Form three physics students. The principals of the sampled schools would be instrumental in providing information through the structured interviews on the factors limiting the use of Information Communication Technology (ICT) in the teaching and learning process. The physics teachers would be instrumental in giving more insights as to why they have not fully implemented the use of ICT in their physics instruction. The Form three physics students would be selected through simple random sampling to provide information on the use of ICT in the teaching and learning of physics. The form three students were selected because they have better understanding of the physics instruction and can provide sufficient information on how physics subject is taught.

5 d. Recruitment Process for Human Research Participants:

Clearly describe how the potential participants will be identified, approached and recruited (use the space provided in the box).

The potential participants for the study would be identified and recruited through simple random sampling using the school attendance register for the teachers and students after getting their consent and research permit from the Ministry of Education in Kenya. The research permit from National Commission for Science, Technology & Innovation (NACOSTI) which is the body that issues licenses to potential researchers who are conducting studies in the country would be applied for so to protect the rights of participants involved in the study. The sampled schools for the study would be identified from the Sub County education office and participants would be identified at the school level by the researcher. The letter of introduction from the UNICAF University and research permit would be important for approaching and describing the importance for the study and explaining to the participants their willingness to participate in the study.

5 e. Research Participants Informed Consent.

Select below which categories of participants will participate in the study. Complete the relevant Informed Consent form and submit it along with the REAF form.

Yes	No	Categories of participants	Form to be completed
☑	☐	Typically Developing population(s) above the maturity age *	Informed Consent Form
☐	☐	Typically Developing population(s) under the maturity age *	Guardian Informed Consent Form

* Maturity age is defined by national regulations in laws of the country in which the research is being conducted.

5 f. Relationship between the principal investigator and participants.

Is there any relationship between the principal investigator (student), co- investigators(s), (supervisor) and participant(s)? For example, if you are conducting research in a school environment on students in your classroom (e.g. instructor-student).

☐ YES ☑ NO

If YES, specify (use the space provided in the box).

6. <u>Potential Risks of the Proposed Research Study.</u>

6 a. i. Are there any potential risks, psychological harm and/or ethical issues associated with the proposed research study, other than risks pertaining to everyday life events (such as the risk of an accident when travelling to a remote location for data collection)?

☐ YES ☑ NO

If YES, specify below and answer the question 6 a.ii.

6 a.ii Provide information on what measures will be taken in order to exclude or minimise risks described in 6.a.i.

N/A

6 b. Choose the appropriate option

		Yes	No
i.	Will you obtain written informed consent form from all participants?	☑	☐
ii.	Does the research involve as participants, people whose ability to give free and informed consent is in question?	☑	☐
iii.	Does this research involve participants who are children under maturity age? **If you answered YES to question iii, complete all following questions.** **If you answered NO to question iii, do not answer Questions iv, v, vi and proceed to Questions vii, viii, ix and x.**	☑	☐
iv.	Will the research tools be implemented in a professional educational setting in the presence of other adults (i.e. classroom in the presence of a teacher)?	☑	☐
v.	Will informed consent be obtained from the legal guardians (i.e. parents) of children?	☑	☐
vi.	Will verbal assent be obtained from children?	☑	☐
vii.	Will all data be treated as confidential? If NO, explain why confidentiality of the collected data is not appropriate for this proposed research project, providing details of how all participants will be informed of the fact that any data which they will provide will not be confidential.	☑	☐
viii.	Will all participants /data collected be anonymous? If NO, explain why and describe the procedures to be used to ensure the anonymity of participants and/or confidentiality of the collected data both during the conduct of the research and in the subsequent release of its findings.	☑	☐

		Yes	No
ix.	Have you ensured that personal data and research data collected from participants will be securely stored for five years?	☑	☐
x.	Does this research involve the deception of participants? If YES, describe the nature and extent of the deception involved. Explain how and when the deception will be revealed, and who will administer this debrief to the participants:	☐	☑

6 c. i. Are there any other ethical issues associated with the proposed research study that are not already adequately covered in the preceding sections?

☐ Yes ☑ No

If YES, specify (maximum 150 words).

6.c.ii Provide information on what measures will be taken in order to exclude or minimise ethical issues described in 6.c.i.

N/A

6 d. Indicate the Risk Rating.

☐ High ☑ Low

7. Further Approvals

Are there any other approvals required (in addition to ethics clearance from UREC) in order to carry out the proposed research study?

☑ YES ☐ NO

If YES, specify (maximum 100 words).

Research Permit from the Ministry of Education in Kenya.

8. Application Checklist

Mark √ if the study involves any of the following:

☑ Children and young people under 18 years of age, vulnerable population such as children with special educational needs (SEN), racial or ethnic minorities, socioeconomically disadvantaged, pregnant women, elderly, malnourished people, and ill people.

☐ Research that foresees risks and disadvantages that would affect any participant of the study such as anxiety, stress, pain or physical discomfort, harm risk (which is more than is expected from everyday life) or any other act that participants might believe is detrimental to their wellbeing and / or has the potential to / will infringe on their human rights / fundamental rights.

☐ Risk to the well-being and personal safety of the researcher.

☐ Administration of any substance (food / drink / chemicals / pharmaceuticals / supplements / chemical agent or vaccines or other substances (including vitamins or food substances) to human participants.

☐ Results that may have an adverse impact on the natural or built environment.

9. Further documents

Check that the following documents are attached to your application:

		ATTACHED	NOT APPLICABLE
1	Recruitment advertisement (if any)	☐	☑
2	Informed Consent Form / Guardian Informed Consent Form	☑	☐
3	Research Tool(s)	☑	☐
4	Gatekeeper Letter	☑	☐
5	Any other approvals required in order to carry out the proposed research study, e.g., institutional permission (e.g. school principal or company director) or approval from a local ethics or professional regulatory body.	☑	☐

10. Final Declaration by Applicants:

16. I declare that this application is submitted on the basis that the information it contains is confidential and will only be used by Unicaf University for the explicit purpose of ethical review and monitoring of the conduct of the research proposed project as described in the preceding pages.

17. I understand that this information will not be used for any other purpose without my prior consent, excluding use intended to satisfy reporting requirements to relevant regulatory bodies.

18. The information in this form, together with any accompanying information, is complete and correct to the best of my knowledge and belief and I take full responsibility for it.

19. I undertake to abide by the highest possible international ethical standards governing the Code of Practice for Research Involving Human Participants, as published by the UN WHO Research Ethics Review Committee (ERC) on http://www.who.int/ethics/research/en/ and to which Unicaf University aspires to.

20. In addition to respect any and all relevant professional bodies' codes of conduct and/or ethical guidelines, where applicable, while in pursuit of this research project.

☑ **I agree with all points listed under Question 10**

Student's Name: EDWIN ANYONYI KUBAI

Supervisor's Name: Alaa Allouch

Date of Application: 17-Mar-2023

Important Note:
Save your completed form (we suggest you also print a copy for your records) and then submit it to your UU Dissertation/project supervisor (tutor). **In the case of student projects, the responsibility lies with the Faculty Dissertation/Project Supervisor.** If this is a student application, then it should be submitted via the relevant link in the VLE. Please submit only electronically filled in copies; **do not** hand fill and submit scanned paper copies of this application.

APPENDIX H

Guardian Informed Consent Form

Guardian Informed Consent Form

Part 1: Debriefing of Participants

Student's Name: EDWIN ANYONYI KUBAI

Student's E-mail Address: kubaiedwin@yahoo.com

Student ID #: **R1806D5512511**

Supervisor's Name: Alaa Allouch

University Campus: Choose from the list

Program of Study: UUM: EdD - Doctorate of Education

Research Project Title: Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya

Date: 01-Apr-2023

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words)**.**

County, Kenya. The government has over the years invested in the provision of ICT resources to schools but there is minimal utilization of the resources for instruction. The findings of this study are expected to identify the impediments on the use of ICT in physics instructions and design new ways of integrating ICT strategies that will help to improve the process of teaching and learning physics. The study would be carried in your school as one of the sampled schools and therefore the information given by the physics teachers and students of your school would be of great importance to the findings of the study. Your contribution as the school principal would also be significant to the study.

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, EDWIN ANYONYI KUBAI **stated above is true and that all**

conditions have been met. Student's Signature: , ensure that all information

Guardian Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should to be signed by the participant's legal guardian

Student's Name: EDWIN ANYONYI KUBAI

Student's E-mail Address: kubaiedwin@yahoo.com

Student ID #: R1806D5512511

Supervisor's Name: Alaa Allouch

University Campus: Choose from the list

Program of Study: UUM: EdD - Doctorate of Education

Research Project Title: Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that the participant is free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of the participation to this study. I understand that all data will remain anonymous and confidential, unless stated otherwise.

I, Jonathan Murunga, the legal guardian of Edward Murunga allow and provide consent that Edward Murunga can willingly participate in the study.

I, Jonathan Murunga, the legal guardian of Edward Murunga have been ensured that verbal consent given by Edward Murunga I will also be taken before the study.

Date: 01-Apr-2023

APPENDIX I

Gatekeeper Letter

Gatekeeper letter

Address: 73598-00200 NAIROBI, KENYA

Date: 21-Mar-2023

Subject: A CONSENT FOR THE STUDY

Dear Principal,

I am a doctoral student at Unicaf University of Zambia (UUZ). As part of my degree, I am carrying out a study the Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya. I am writing to enquire whether you would be interested in participating in this research.

Subject to approval by Unicaf Research Ethics Committee (UREC) this study will be using a questionnaire and structured interview schedule to collect data from the participants. The main purpose of the study to investigate factors limiting the use of ICT in the process of physics instruction despite the government intervention in provision of ICT resources to public secondary schools in the country. The study is meant to inform the government on any possible impediment to the effective utilization of ICT resources in order to enhance 21st Century skills among learners. The supervisor for this project is Dr. Alaa Allouch.

The study would involve data collection from the school principal, Physics teachers and the current Form three physics students. The Physics teachers and students would respond to a structured questionnaire and you as the school principal would respond to a structured interview. The purpose of this letter is to seek consent for accessing your school premise in order to collect data that would be significant for the completion of this study. Responding to the questionnaire and interview schedule would require 30 minutes respectively to complete.

Thank you in advance for your time and for your consideration of this project. Kindly please let me know if you require any further information or need any further clarifications.

Yours Sincerely,

Edwin Kubai

Student's Name: EDWIN ANYONYI KUBAI
Student's E-mail: kubaiedwin@yahoo.com

Student's Address and Telephone: P.O Box 73598-00200, NAIROBI, +254725945612
Supervisor's Title and Name: Dr. Alaa Allouch
Supervisor's Position: Lecturer
Supervisor's E-mail: a.allouch@unicaf.org

APPENDIX J

Informed Consent Form

Informed Consent Form

Part 1: Debriefing of Participants

Student's Name: EDWIN ANYONYI KUBAI

Student's E-mail Address: kubaiedwin@yahoo.com

Student ID #: R1806D5512511

Supervisor's Name: Alaa Allouch

University Campus: Unicaf University Zambia (UUZ)

Program of Study: EdD - Doctorate of Education

Research Project Title: Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya

Date: 22-Mar-2023

Provide a short description (purpose, aim and significance) of the research project, and explain why and how you have chosen this person to participate in this research (maximum 150 words).

The main purpose of the study is to investigate factors limiting the use of Information Communication and Technology (ICT) in Physics instruction in public secondary schools in Nairobi County, Kenya. The government has over the years invested in the provision of ICT resources to schools but there is minimal utilization of the resources for instruction. The findings of this study are expected to identify the impediments on the use of ICT in physics instructions and design new ways of integrating ICT strategies that will help to improve the process of teaching and learning physics. The study would be carried in your school as one of the sampled schools and therefore the information given by the physics teachers and students of your school would be of great importance to the findings of the study. Your contribution as the school principal would also be significant to the study.

The above named Student is committed in ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to the participants.

Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted.

All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

I, EDWIN ANYONYI KUBAI **, ensure that all information stated above is true and that all conditions have been met.**

Student's Signature: Edwin Kubai

Informed Consent Form

Part 2: Certificate of Consent

This section is mandatory and should be signed by the participant(s)

Student's Name: EDWIN ANYONYI KUBAI

Student's E-mail Address: kubaiedwin@yahoo.com

Student ID #: R1806D5512511

Supervisor's Name: Alaa Allouch

University Campus: Unicaf University Zambia (UUZ)

Program of Study: EdD - Doctorate of Education

Research Project Title: Determinants Constraining the Integration of Information and Communication Technology (ICT) in Physics Instruction in Secondary Schools Within Nairobi County, Kenya

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions, and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation to this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Participant's Print name: Beatrice Agunga

Participant's Signature: Beatrice

Date: 22-Mar-2023

If the Participant is illiterate:

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had an opportunity to ask questions. I confirm that the aforementioned individual has given consent freely".

Witness's Print name: NA

Witness's Signature: NA

Date: