

**BIOLOGY TEACHING AND LEARNING AND ACHIEVEMENT OF
LEARNING OUTCOMES IN SECONDARY SCHOOLS IN NAIROBI CITY
COUNTY, KENYA**

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**A RESEARCH THESIS SUBMITTED IN FULFILLMENT OF THE
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DECLARATION

I declare that this thesis is my original work and has not been presented in any other university/institution for consideration of any certification. This thesis has been complemented by referenced sources duly acknowledged. Where text, data, graphics, pictures or tables have been borrowed from other works, including the internet, the sources are specifically accredited through referencing in accordance with anti-plagiarism regulations.

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DEDICATION

I dedicate this thesis to my father, the late Richard Osugo Mageto, and to my mother Prisca Mogotu. Your support, prayers and love was/is immeasurable! To my daughter the late Jeanette- Purity and to my son Sunday -Victor. Children are a gift from God. To my nephews and nieces - Gregory, James, Catherine, Cecilia and Naserian.

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ABBREVIATIONS AND ACRONYMS

CBC	Competence Based Curriculum
CDE	County Director of Education
CEMASTEA	Centre for Mathematics, Science and Technology Education Africa
COVID 19	Corona Virus Disease 19
CKS	Content Knowledge Skills
DNA	Deoxyribo-Nucleic Acid
FGD	Focused Group Discussion
HoD	Head of Department
ICT	Information Computer and Technology
INSET	In-service training
KICD	Kenya Institute of Curriculum Development
MOEST	Ministry of Education Science and Technology
NACOST	National Council Science and Technology
NESP	National Education Sector Plan
NoS	Nature of Science
RoK	Republic of Kenya
SMASSE	Strengthening Mathematics and Science in Secondary Education
SPS	Science Process Skills
WERK	Women Educational Researchers of Kenya

ABSTRACT

Researchers identify Biology as an important scientific discipline that contributes to vital scientific innovations such as genetic engineering and medicine. Despite this significance, examination reports in Kenya indicate that from 2013 to 2023, students have continually achieved low outcomes in Biology in the National Examinations. This, therefore, implies that there could be challenges in the teaching and learning of Biology, resulting in poor learning outcomes. Hence, this study sought to establish how the teaching of Biology influences students' learning and achievement of learning outcomes. The specific objectives were to: assess the utilization of teaching and learning resources in Biology teaching and its influence on the achievement of learning outcomes; evaluate the application of Biology teaching in everyday life and its influence on the achievement of learning outcomes; assess the pedagogical techniques used in Biology teaching and its influence on the achievement of learning outcomes and; examine the integration of ICT in Biology teaching and its influence in the achievement of learning outcomes. The study employed mixed-methods research approach using explanatory sequential design. This study was guided by two theories, namely: Zone of Proximal Development Theory and Scaffolding Theory, and Social Constructivism Theory. The study started with a survey followed by qualitative study of selected schools in accordance with the findings of the survey. The study locale was Nairobi City County, where it targeted 114 public secondary schools. The sample size was 114 for the quantitative phase and 57 for the qualitative phase. Data was collected using questionnaires, in-depth interview guides, Focused Group Discussion (FGD) guide and class observation guide. The study respondents were: Biology teachers, students and Biology specialists from: Kenya Institute of Curriculum Development (KICD), Centre for Mathematics, Science and Technology Education Africa (CEMASTE) and Lecturers of Biology education at Kenyatta University (KU). The findings of the study were: utilization of teaching and learning resources in Biology teaching was inadequate and could only enhance achievement of low order cognitive, basic science process skills and poor attitude learning outcomes; application of Biology to everyday life was insufficient and hence influenced achievement of low order cognitive outcomes, basic science process skills and lack of interest in Biology learning outcomes; ICT integration was unsatisfactory and enhanced achievement of low order cognitive outcomes, inadequate skills outcomes and low interests in Biology. The study concluded that teaching of Biology was deficient. This study therefore recommends that teacher training institutions should organize for innovative approaches to train teachers on active pedagogy, science process skills, the nature of science and ICT integration; KICD should ensure that curriculum guidelines are intentional on pedagogical techniques, the science process skills and the nature of science.

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 Introduction

This chapter presents the introduction and background information of the study, the problem under study, and the purpose for which the study was carried out. Further, the chapter presents the specific study objectives and the questions that the study sought to answer. The chapter goes on to present the significance of the study and the specific assumptions that the study made. In addition, the chapter presents issues about the limitations and the delimitations of the study. Towards the end, the chapter presents a discussion of the conceptual framework that guides the study and the theoretical framework. Finally, the chapter presents the operational definition of terms.

1.2 Background to the Study

Science has and continues to accelerate socio-economic development in all the industrializing countries of the world (Xue & Li, 2021). Productivity in health, technology, education, and energy has been realized through scientific research and innovation. Evidence from research has shown that education systems are not up to the challenge in science teaching, leading to a decline in achievement of learning outcomes in science disciplines (Fernandes, Rodrigues, & Ferreira, 2019). Further, research studies note that concerns raised regarding science teaching, including the methodology of teaching science and the introduction of technologies, among other concerns, have not been addressed. Given the place of science in socio economic development of a country, there is need for countries to ensure that sciences are taught in a manner that exemplifies high quality (Xue & Li, 2021).

Many researchers often identify Biology as one of the most important parts of scientific discipline, contributing significantly to the health and lives of people (Nizomova, 2023).

For instance, the recent discoveries of vaccines for Coronavirus Disease 19 (COVID-19), the disease which almost brought the whole world to a standstill, were through a rigorous biological research process. Biology has further contributed to scientific health innovations such as blood transfusion, organ transplantation and genetic engineering which are lifesaving discoveries. The knowledge of genetics, an aspect of Biology, has revolutionized determination of paternity disputes and identification of culprits of serious crimes with precision and certainty through Deoxyribo-Nucleic Acid (DNA) sequencing and profiling. Thus, the value of Biology and the need to research about it cannot be overemphasized since it is a stepping stone to good health and socio-economic development (USAWA, 2024).

Globally, many countries have invested massive resources in the teaching and learning of Biology and other sciences, as illustrated by nations such as Australia, Malaysia, Ireland, Chile, South Korea, China and Finland (Boudry & Pigliucci, 2018). In Australia, for instance, policy review in Science learning, including Biology, has focused on student outcomes and the curriculum (Timms, Moyle, Weldon, & Mitchell, 2018). This focus on teaching sciences and Biology implies that Australia as a country has appreciated the need to invest in the teaching of Biology and other sciences as they can contribute to socio-economic development.

Turkey has also devoted her resources to promoting Biology and science education as a whole. The country has made changes in the Biology and science curricula to achieve the desired goal of attainment of socio-economic development (USAWA,

2024). In particular, objectives of the Biology curriculum have emphasized the importance of inquiry in learning in order to promote problem-solving skills.

In the USA, measures have been put in place to enhance teaching of Biology and other science subjects because of the realization of the role they play in the development of a country (Mims, Lee, & Kuldell, 2025). To this effect, science learning centers that offer skills development to science teachers have been established in the USA (Gatica, 2024). The centers enhance teacher education in Biology and other science subjects for the purposes of effective curriculum delivery and high achievement of learning outcomes.

African countries have also made efforts in promoting Biology and science education. In Nigeria, for example, the Federal Ministry of Science and Technology of Nigeria has popularized Biology education and other science subjects for the country's economic development (FME, 2018).

In Kenya, the Vision 2030 Program identifies Biology as a science which is a pillar for social and economic development. The Sessional Paper No.1 of 2005 further amplifies the role of teaching in the promotion of science education, of which Biology is included. There are two other Sessional Papers, namely No. 14 of 2012 and No. 2 of 2015, supporting the idea of high-quality education for sciences. The development of the health sector in Kenya, just like in other countries, depends on quality Biology teaching. The Kenya National Examination Council reports of 2013-2020 have, however, shown poor achievement of learning outcomes in Biology (see table 1.1). This being the scenario, there is a need to examine the teaching of Biology so as to rectify the dismal achievement of learning outcomes in Biology (KNEC, 2022).

Table 1.1: KCSE Examination Results 2013-2019

Year	Subject	2013	2014	2015	2016	2017	2018	2019	2020
% Average	Biology	31.63	31.83	34.80	29.18	18.93	25.69	25.69	
score per	Chemistry	24.50	32.16	34.83	23.71	24.05	26.88	26.09	
subject	Physics	40.10	38.84	43.68	39.76	35.05	34.27	32.59	

Source: KNEC Reports 2013-2019

From Table 1.1, it is evident that among the pure science subjects, namely: Biology, Chemistry and Physics, Biology has continually recorded the lowest achievement of learning outcomes throughout the years. This status called for urgent investigation into the teaching of the of Biology subject so as to lay bare the challenges experienced and suggest possible remedies to the current state. The researcher conducted the study in Nairobi City County, which is among the 47 counties in Kenya. Nairobi County was selected for this study because it is one of the counties that consistently achieved low outcomes in Biology from 2013-2020 (see table 1.2)

Table 1.2: Nairobi County Biology Mean Score 2013-2020

Year	2013	2014	2015	2016	2017	2018	2019	2020
Mean	2.698	2.826	2.932	3.021	2.769	2.834	2.976	3.234
score (points)								

Source: KNEC Reports 2013-2019

The highest number of points which a candidate can achieve is 12, which represents an 'A' grade worth 80% of the marks or more. The lowest number of points a candidate can achieve is 1 which represents an 'E' grade worth 29% of the marks or below. From the above table, Biology scores in public schools in Nairobi County between the years 2013 and 2020 ranged from 2.698 to 3.234. This was an average grade of a 'D' which is worth 35-39% of the marks. These results clearly indicate

that achievement in Biology in public schools in Nairobi County is below average hence the need of this study on the teaching of Biology in Nairobi County so as to establish the causes of this phenomenon and suggest remedies for the same.

Besides the low achievement of learning outcomes, Nairobi City County was selected for this study because it has the most diverse of characteristics representing the Kenyan educational context as a whole such as: diverse ethnic groups, varied socio-economic status and varied representative categories of schools in Kenya. The county, therefore, was the most preferable location for this study because it gives a good representation of the people of Kenya.

1.2.1 Biology Teaching and Learning

Biology teaching involves providing a stimulus for students' learning of Biology content, knowledge, experiences, skills, and attitudes. Teaching, therefore, is what enhances students' learning. According to Clarke and Hsu (2023), to measure progress in learning, teachers create checkpoints for students to provide feedback so that they know how to improve their teaching. Teaching of Biology is therefore what provides the basis for learning and assessing of learning outcomes in the subject. Most students report that mastering Biology concepts is a struggle and that they do not understand Biology because teachers do not clarify what the students already know (AlAfnan, 2025)

AlAfnan (2025) further asserts that students hold onto their preconceptions if they are not helped to make clarifications. Teachers must therefore identify prior preconceptions about students' understanding of Biology concepts and use this information to plan and execute the teaching of Biology. The teacher should then orchestrate learning experiences and teaching techniques to confront students'

misconceptions and help them understand scientific concepts. Students only learn if they make sense of the learning, hence teachers should endeavor to create sense-making instances during the teaching of Biology (Superfine, Ko, & Goldman, 2022). Teachers' use of teaching resources, application of the Biology curriculum to everyday-life context, and use of suitable pedagogical techniques that promote inquiry learning and ICT integration can help students make sense of Biology by visualizing conceptual knowledge, forming hypotheses, critiquing, analyzing, and understanding Biology.

Utilization of teaching and learning resources is a key aspect in teaching Biology. A study by Chatzikyriakidou et al (2022), showed that Biology teaching requires integration of resources presented in carefully interrelated steps for proper understanding of concepts. Proper planning and sequential use of various teaching and learning resources, including the material and the infrastructure resources, is therefore what can help achieve different needs of learners as the resources help in making sense of Biological concepts. The high cost of teaching and learning resources, however, is an impediment to the availability and utilization of teaching and learning resources (Chatzikyriakidou, Tacloban, Concepcion, & McCartney, 2022). In their study, Chatzikyriakidou et al recommend that it is important for educators to design and make teaching and learning material resources for effective teaching. Thus, underutilization of material learning resources should not arise as most of the resources can be made from locally available materials.

Apart from utilization of teaching and learning resources, many recent science education reforms have included application of the Biology curriculum into everyday-life context as a central tenet (Timms, Moyle, Weldon, & Mitchell, 2018).

Application of the Biology curriculum into everyday life implies intentionality in linking the Biology curriculum to its daily applications and not through coincidence or as a background assumption. Clark & Hsu (2023) noted two important aspects in application of Biology curriculum into everyday life context: 1) the process skills of doing science and 2) the Nature of Science.

According to Nicholas et al (2020), examples of SPS include: observing, classifying, measuring, predicting, identifying, and defining variables, collecting and transforming data, making tables of data and graphs, describing relationships between variables, interpreting data, manipulating materials, formulating hypotheses, designing investigations, drawing conclusions and generalizing information.

The SPS outlined in the secondary Biology syllabus (Republic of Kenya, 2002) include: observing, classifying, communicating, measuring, predicting, inferring, identifying and controlling variables, formulating and testing hypotheses, defining, interpreting data, experimenting and constructing models. Studies have shown that there is an attempt by teachers to practice basic science process skills such as observation, measurement, experiments, and predictions but not yet the higher SPS skills such as hypothesis making, controlling variables and construction of models (Clark & Hsu, 2023). On the other hand, the major aspects of the nature of science include: Science is tentative but robust; no single method of doing Science exists; creativity and imagination influence Science; there is a clear distinction between observation and conclusions; there is a distinction between theory and law; and that there is subjectivity and the social cultural context in Science. There is a need for researchers to establish why the teachers are shying away from the higher SPS and

adequately incorporating the nature of science which have been reported to bring out a clear understanding and interest in Biology.

The challenge with application of Biology content knowledge into everyday-life context has been the perception that it may conflict with assessments or other systemic demands (L'Heureux, 2021). The fear of conflicting the application of the curriculum into everyday-life context with assessments notwithstanding, the Biology teachers need to create instances for the application of science process skills and the nature of science in the course of teaching. Curriculum guidelines as well should aspire to bring the Biology curriculum into a social reality in which learners can associate with. Researchers have noted a decline in achievement of learning outcomes in Biology and have pointed to the abstractness of the Biology curriculum as the main possible reason (Clark & Hsu, 2023). There is therefore a need to evaluate the application of the Biology curriculum into everyday context and achievement of learning outcomes among learners.

In addition to application of Biology content knowledge into everyday-life context, use of relevant pedagogical techniques is paramount in teaching Biology. Research on teaching no longer supports a passive style of teaching (Xue & Li, 2021). Passive pedagogy, for example, explanation; question and answer; demonstration; and lecturing strategies of teaching, only promotes memorization and rote learning. Contrary to this assertion about lecturing strategy, researchers report that many teachers employ passive style in teaching Biology, citing challenges that do not allow them to use active-learning methods (Keengwe, 2022). Concerted efforts should thus be made, the challenges faced by teachers notwithstanding, so that teachers move towards active pedagogy. Active learning pedagogy, such as problem

solving; collaborative and cooperative learning; project and discovery learning on the other hand is likely to empower learners to acquire knowledge that can be useful in making them innovators and problem solvers in the 21st century.

Apart from the use of active learning pedagogy techniques, integration of ICT in teaching Biology can enhance active learning. According to MOEST (2015), ICT integration is what can promote learning in today's world. Insufficient computers in schools and lack of training of teachers in IT have been major challenges facing the integration of computer technology into the instruction process. This notwithstanding, this study assessed the use of ICT integration in teaching and how it influences achievement of learning outcomes in Biology. Achievement of low learning outcomes from the discussion was therefore suspected to be due to lack of creation of sense-making instances during the teaching of Biology. Researchers argue that failure to investigate the teaching process makes it difficult to interpret the learning outcomes and their subsequent relation to the possible determinants (Clark & Hsu, 2023). This study therefore, assessed the Biology teaching process and the achievement of learning outcomes.

1.2.2 Achievement of Learning Outcomes

How teaching is carried out is what defines the learners' outcomes or results of the objectives or aims of a curriculum (Gatica, 2024). Learning outcomes in terms of expected knowledge, skills, attitudes and behaviors are fundamental benchmarks designated to hold education systems, schools and teachers accountable for the learners' achievements (Toh & Zaidatun, 2024). Learning outcomes are multidimensional, meaning that learning may be apparent from changes in cognitive, affective or skill capacities.

Learning outcomes should therefore be judged from a holistic view and not just from one dimension so that correct judgment can be given about teaching and learning. Teacher characteristics including teacher qualifications, content knowledge, teaching practices and teacher-student interactions may promote learning and achievement of learning (Mims, Lee, & Kuldell, 2025). But these characteristics explain very little of the variation in achievement of learning outcomes. This study, therefore, sought to explore teaching practices and the kind of learning outcomes they promote.

Zaman, Ghosh, & Chakraborty (2025) outline three types of learning outcomes namely: 1) cognitive 2) affective and 3) skill based. According to Bloom's taxonomy, cognitive outcomes are delineated into six levels of learning hierarchically (Alafnan, 2025). They are remembering, understanding, applying, analyzing, evaluating, and creating. Attainment of outcomes, which is characterized by remembering and understanding, is therefore the lowest cadre of cognitive learning. When learners can portray understanding, use knowledge in new or unknown situations, and build their own knowledge, they are considered to have developed sufficient skills implied in effective learning (UNICEF, 2022). Teachers should therefore make efforts to assist learners achieve higher cognitive outcomes such as evaluation and creation in the teaching and learning process.

In the national Biology examinations, the six levels of cognitive outcomes outlined in Bloom's taxonomy are tested. From the analysis of Kenya Certificate of Secondary Education (KCSE) 2013-2020, many learners failed questions that tested higher thinking skills. Many students at KCSE were only able to demonstrate learning outcomes which only involve remembering of concepts. Worse still, many others displayed very little achievement even in the items that required remembering

of concepts. With many students achieving such low outcomes in Biology, a life science, there is need to examine the teaching of Biology and its influence on achievement of outcomes.

Filmer, Molina & Wane (2020) classify skill-based outcomes into three categories: learners' ability to observe and describe the skills they are using, the ability of learners to practice the skill faster with less error as they proceed, the ability of the learners to consistently perform the skill well. In Kenya, skill-based assessment is done in the KCSE practical paper (Biology paper 3). According to Filmer et al. (2020), skill-based outcomes can be assessed through (a) timed observation (b) steps identified by the student during hands-on performance (c) a post-performance structured situational interview of the student and (d) the ability of learners to solve a single task alongside interference tasks. Examination reports have shown that many learners get poor results in Biology practical skills. Biology skills are essential in today's world and with low skill achievement, there is fear for inadequate biotechnological advancement which is important for a country's development. This study investigated the kind of teaching practices that promote achievement of skill-based learning outcomes.

Affective based learning outcomes on the other hand are attitudinal learning outcomes. Attitudinal outcomes determine a behavior or performance of a learner. They are measured through discretion, scale such as agree or disagree. KNEC (2021) notes that assessment of affective learning outcomes is often ignored in Kenya even though it is important. This study investigated the teaching practices in Biology that promote achievement of affective learning outcomes through classroom observations and interviews.

Despite the categorization of learning outcomes, achievements of learning outcomes are not discrete but interrelated. Change in one learning outcome implies change in another. Learning outcomes are intimately connected to teaching of the curriculum and therefore an integral output-focused approach to teaching, learning and assessment would be important (KNEC, Competency Based Assessment Framework, 2021). Thus, by treating learning outcomes as a dependent variable, researchers can therefore qualify the differences in Biology teaching, since teaching is directly proportional to achievement of outcomes.

1.3 Statement of the Problem

In the quest for Kenya to achieve the desired socio-economic growth and health goals as stipulated in the Kenya Vision 2030, emphasis has been placed on science and technology. Development of the health sector in particular heavily relies on Biology and, consequently, the teaching of Biology. Unfortunately, achievement of Biology learning outcomes has been poor as portrayed in the national examinations in the Kenya Certificate of Secondary Education (KCSE) results (refer to table 1.1). With many students achieving such low outcomes in Biology, there is likelihood for inadequate advancement in health and economic growth which is vital for a country's development. There is therefore a need to understand how teaching of Biology is carried out in schools and its effect on achievement of learning outcomes if this status of achievement of low learning outcomes is going to be dealt with.

1.4 Study Purpose

The study purposed to investigate the teaching of Biology discipline and achievement of learning outcomes in an effort to recommend possible solutions

towards achieving quality teaching and high attainment of learning outcomes in Biology.

1.5 Study Objectives

The study sought to:

- i. Assess the utilization of teaching and learning resources in Biology teaching and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- ii. Evaluate the application of Biology curriculum in everyday life context and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- iii. Assess the pedagogical techniques used in Biology teaching and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- iv. Examine the integration of ICT in Biology teaching and its influence in the achievement of learning outcomes in public secondary schools in Nairobi County.

1.6 Research Study Questions

The study sought to answer the following questions:

- i. How does the utilization of teaching and learning resources in Biology teaching influence the achievement of learning outcomes in public secondary schools in Nairobi County?
- ii. How does the application of Biology curriculum in everyday life context influence the achievement of learning outcomes in public secondary schools in Nairobi County?

- iii. How do the pedagogical techniques used in teaching Biology influence the achievement of learning outcomes in public secondary schools in Nairobi County?
- iv. How does ICT integration in teaching Biology influence the achievement of learning outcomes in public secondary schools in Nairobi County?

1.7 Study Significance

The study is important at different levels and to different people and institutions. It can help individual Biology educators, and from institutions such as CEMASTEIA, universities and colleges, who will manage to read this study, in empowering Biology teachers to improve their teaching practices from an informed stance. Consequently, the students of Biology may benefit from learning from well trained and informed teachers and thus high achievement of learning outcomes in Biology.

The findings and recommendations of this study are of benefit to the Quality Assurance Officers (QASOs) and the Teachers' Service Commission (TSC) by informing them about the teachers' challenges in Biology teaching. This could help them design appropriate in-service trainings which can help alleviate teachers' challenges in Biology teaching.

In addition, this study informs curriculum developers such as KICD in coming up with more adequate and precise curriculum guidelines and resources for example syllabus, teachers' guides and text books.

Further, it adds to the existing knowledge of Biology teaching and therefore can provide a basis for further studies by other researchers.

1.8 Study Assumptions

This research made the following assumptions:

- i. Biology teachers in public secondary schools in Nairobi County teach and assess students according to the curriculum guidelines.
- ii. Biology teachers in public secondary schools in Nairobi County face challenges in Biology teaching
- iii. Respondents truthfully responded to the demands of the study.

1.9 Study Limitations

The study had the following limitations:

- i. There was a possibility that some respondents in the sampled schools were exaggerating their responses to show their schools' prowess in teaching Biology. The purpose of the study was communicated to the respondents and assurance of confidentiality and anonymity given.
- ii. It was feared that some respondents may find it difficult to spare time to participate in the study due to their tight schedules. The researcher sought a mutual agreement on a convenient day in such a case.
- iii. Some respondents were hesitant at first to respond to queries, until they were assured by their superiors that it was ok to proceed with the study. The researcher allayed such fears by displaying the authentic documents required for such a study
- iv. A section of respondents approached the interview as an appraisal of their performance, rather than a fact finding study. Thus, they shied away from shedding light on aspects they deemed negative on their overall performance. To counter this, the researcher explained clearly the objectives of the study.

1.10 Study Delimitations

The researcher delimited the study to Nairobi County to ensure that it is manageable. As a result, assessment of Biology teaching in the other 46 counties in Kenya was not included. Within Nairobi County, only public secondary schools in the County were included in the study, leaving out private secondary schools. Further, among Biology learners, only form three learners participated in the study.

1.11 Theoretical Framework

This study was guided by two theories 1) Zone of Proximal Development (ZPD) and Scaffolding theory by Vigotsky and 2) Social Constructivism theory by Vygotsky (Saleem, Kausar, & Deeba, 2021)

Zone of Proximal Development (ZPD) and Scaffolding theory

This theory by Vygotsky states that the Zone of Proximal Development (ZPD) is the conceptual rift between what a student is and is not able to accomplish independently. Vygotsky in his theory states that teachers need to offer professional and career support to their students and that could be through the identification of ZPD and helping them achieve tasks that exceed it.

This theory guides that in identifying the ZPD, the teaching process should provide sense making opportunities for meaningful learning. The teaching process should confront what learners already know and guide them to the development of new knowledge. The teaching process should therefore promote application of knowledge to everyday life context within the society (Bustami et al, 2018). This includes, according to Mandasari et al (2021), employing the use of science process skills and the nature of science. This theory guided the second objective which was to evaluate

the application of Biology curriculum into everyday life context and achievement of learning outcomes.

1) Social Constructivism Theory

The Social Constructivism theory by Vygotsky states that learners are active players in the construction of knowledge as opposed to being passive recipients. People have different experiences and that informs their understanding of the world around them. According to this theory, teaching should give a chance for students' active learning to enable them construct their own knowledge rather than acquisition of knowledge by rote that exists somewhere outside the learner. Social constructivism theory provides a useful framework for teaching and learning Biology (Timms, Moyle, Weldon, & Mitchell, 2018) as it guides that teachers through active pedagogy, utilization of teaching and learning resources and ICT integration offer an opportunity for learners to develop their own understandings through questioning of the status and have their own beliefs. This theory addressed three objectives of this study namely: to evaluate the pedagogical techniques and achievement of learning outcomes; to examine the utilization of teaching and learning resources and achievement of learning outcomes and ICT integration and achievement of learning outcomes (Saleem, Kausar, & Deeba, 2021).

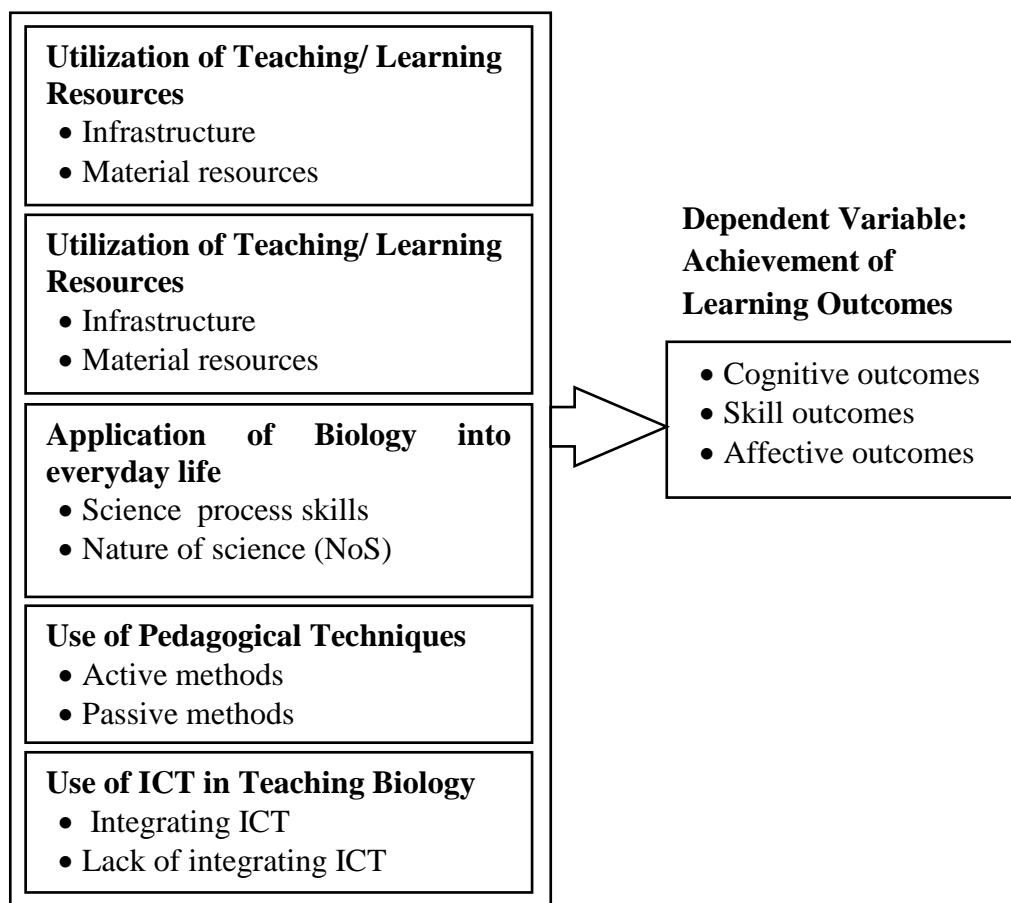
From these two theories discussed here, effective teaching and learning process should lead learners into the attainment of multidimensional learning outcomes such as cognitive, affective and skills. As students, therefore, make sense of the knowledge, skills and attitudes, they construct their own meaning in the learning process leading to the achievement of desired learning outcomes.

1.12 Conceptual Framework

The conceptualization of this study is as illustrated in figure 1.1

Figure 1.1: Conceptual framework

Independent Variable: Biology Teaching and learning



Source: Researcher's design

Drawing from figure 1.1, the independent variable is Biology teaching and learning. The indicators of Biology teaching and learning entails utilization of teaching and learning resources, application of Biology curriculum into everyday life context, the utilization of active pedagogical techniques and the ICT integration. The dependent variable is the achievement of learning outcomes. The indicators for achievement of learning outcomes include the achievement of cognitive, skills and affective

outcomes. The effective interaction of the named independent and dependent variables determines the level of achievement of Biology learning outcomes.

1.13 Operational Definitions of Central Terms

Achievement: Attainment of learning outcomes in terms of cognitive, affective and skills.

Active Learning Pedagogy: Learner centered teaching methodology involving active participation of learners and their construction of own meaning of knowledge.

Application of Biology Curriculum into Context: Intentionality in situating the Biology knowledge in a situation that authenticates its application or observation in everyday life.

Biology Curriculum: Guidelines for Biology including syllabus, teacher's guides and textbooks.

ICT Integration: Infusing information from computers and digital devices in teaching.

Learning Outcomes: What learners are expected to do, know and value.

Passive Learning Pedagogy: Teacher-centered methodology involving transferring of knowledge to learners for memorization and reproduction.

Pedagogical Techniques: Teaching methods/practices that provide a learning stimulus for students

Teaching and Learning Resources: Infrastructure, Material and digital resources used for teaching Biology.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter reviews available literature on: the utilization of the teaching and learning resources and achievement of learning outcomes, the application of Biology curriculum in everyday life and the achievement of learning outcomes, the use of pedagogical techniques and the achievement of learning outcomes and the ICT integration and the achievement of learning outcomes.

2.2 Utilization of Teaching and Learning Resources and Learning Outcomes

OECD, (2023) emphasizes the need to embrace new ways of teaching using contemporary teaching and learning resources. OECD classifies teaching-learning resources as: 1) infrastructure such as laboratories 2) material resources such as textual materials including textbooks, teaching/learning aids such as charts, maps, graphs and pictures. OECD, (2023), further highlights that material resources provide for a logical delivery of content in a stable structure that may become object of reflection and discussion. Utilization of material and infrastructure resources is therefore vital in offering learners suitable experiences that promote learning leading to achievement of learning outcomes. A study by Juniar, Fardilah, & Tambunan (2021) noted that the Utilization of relevant learning resources can achieve effective learning contributing to high achievement of learning outcomes. This study further validates the importance of teaching and learning materials in enhancing learning.

There is a huge spectrum of apparatus that can be used for the teaching and learning of Biology, ranging from specimens, important equipment, chemicals and reagents, plus charts and models and can enhance high achievement of learning outcomes

(Keengwe, 2022). Keengwe (2022) however noted in his study that most schools do not have adequate resources for the learners to use and even for the few that are available are not utilized as they should. Adegbite, (2022) adds in his study that in schools with inadequate resources the few that are available are mainly used by teachers and not students. Consequently, assessment reports have shown a decline in the achievement of learning outcomes. These findings therefore indicate that effective utilization of resources in teaching Biology is yet to be realized.

In Mbatia, Wanjala, & Edome (2020)'s study carried out in Kenya, there was a better performance recorded by learners who were taught with the help of the resources for teaching and learning as compared to those who were taught without or with little of these resources. These findings therefore pointed to a positive correlation of utilization of resources and high achievement of learning outcomes. This study however did not tease out the specific learning outcomes that utilization of teaching resources achieved. According to Mbatia, Wanjala, & Edome (2020) among the material resources, textbooks are commonly used because they are easy to use and are readily available. Apart from availability and ease of use of textbooks, they provide a logical way to present content, provide diagrams and illustrations, and usually contain review activities and tests to enhance learning (Otieno, 2022). Textbook resources may be quite reliable but promote memorization and rote learning which is discouraged by researchers.

According to a study by Masu & Abe (2025), materials enhancing visualization in learning Biology such as charts and graphs can to a great extent promote students' comprehension of Biology. Worksheets resources can further assist students in understanding the material and applying concepts to fresh situations. A study by

Buffalari, (2022) indicated that using worksheets as a type of active learning can help students understand the ideas of genetics. By using work sheets, Biology students' critical thinking abilities can be improved. Graphs, charts and worksheets are therefore useful material resources in teaching Biology as they can assist in comprehending biological concepts.

Use of infrastructure in teaching Biology is a key resource. A study by Bwalya, (2023), which aimed at investigating the impact of the availability of infrastructure such as laboratories on learning outcomes of secondary school learners in Zambia, found that there was no statistical difference in effect on learner academic achievement in final examinations. This finding showed that although Biology is a science subject, it is not only taught but also learnt efficiently from the science laboratory. It is the entire setting for learning therefore that matters and not the physical space. Despite this remarkable finding, that the lack of science laboratories does not have an influence on teaching and consequently on academic achievement, availability and the experience of learning from the laboratory cannot be underestimated. Many argue that constructivist teaching practices are likely to occur more often in the laboratory than in the regular classroom (Boudry & Pigliucci, 2018). This is because the laboratory environment allows students to engage in hands-on experimentation and observation, which can deepen their understanding of biological concepts and enhance achievement of learning outcomes.

A study by Mims et al (2025) which investigated the impact of library use on students' academic achievement in Biology in Nigeria found that library use significantly predicted students' academic performance in Biology. It is therefore important for teachers to refer students to use the library and its resources. Masu and

Abe, (2025) conducted a study in Japan to find out if the use of a television in teaching Biology promoted achievement of learning outcomes. The study indicated that while the television program was successful in piquing the students' interest in Biology, it had no significant effect on achievement of learning outcomes. As much as learning Biology inside the Television room may not improve achievement of learning outcomes, it has the potential to facilitate student engagement and motivation, and in turn this serves as a catalyst for deeper learning.

According to Superfine et al (2022), who carried out a study to find out the effect of computer simulations in achievement of learning outcomes in teaching Biology, computer-based simulations significantly improved students' understanding of abstract biological concepts. It is therefore important for Biology teachers to utilize computer rooms to show computer-based simulations to their students to enhance students' learning experiences. Similarly, the use of Botanical gardens as a resource of teaching Biology has been known to offer a special opportunity for students to explore and learn about plants. Krtková, (2024) carried a study in the USA to investigate the impact of a botanical garden on students' outcomes. The study found that students who visited the botanical garden demonstrated a higher degree of cognitive skills, such as observation, analysis, and interpretation, compared to those who did not visit the botanical garden. Botanical gardens can therefore enhance higher skills in learning about plants.

A study by Schilbert and Scheersoi, (2022) which investigated the effect of aquarium visits on students' outcomes showed that students who participated in an aquarium-based program demonstrated high understanding of aquatic and biological ecosystems, including the interrelationships among living organisms. Students

should therefore be exposed to environments outside the classroom to enhance achievement of outcomes. In another study, Okur, Uzoğlu, and Bozdoğan, (2019) investigated in the USA the impact of teaching students in a zoo on students' learning. It was established that zoos can improve students' critical thinking skills and scientific inquiry e.g. hypothesis testing and data analysis, compared to those who did not take part in the programs. School visits to the zoo should thus be encouraged and facilitated by school administrations and parents. The use of zoos and aquariums in Biology teaching may however bring to attention ethical and animal welfare concerns. Therefore, educators should carefully consider the ethical implications while using aquariums and zoos in the teaching of Biology.

2.3 The Application of Biology Curriculum into Everyday Life Context and Learning Outcomes

Many students have reported that Biology is difficult to understand because it has numerous abstract concepts (Chatzikyriakidou, Tacloban, Concepcion, & McCartney, 2022). To help students understand Biology, efforts should be made to make it relevant and applicable to everyday life. Application of Biology curriculum into everyday life includes instilling Science Process Skills (SPS) in students such as observation, measurement, hypothesis-making and inference-making. Also, it involves aiding students in appreciating the nature of science in Biology and in the society where Biology is learned (Fernandes, Rodrigues, & Ferreira, 2019). These studies have done well in suggesting ways that teachers and educators can make Biology more relevant to learners. The studies have however not investigated the extent to which application of Biology curriculum into everyday life affects the achievement of learning outcomes.

Biology is not just about a body of facts, laws and theories, but the method of acquisition through the Science Process Skills (SPS) is a major component of Biology (Keengwe, 2022). SPS often brings the context that influences learning, even when it is not explicitly addressed or designed for. The application of science process skills enhances a student's intellectual and emotional processing (Morselli & Hand, 2018).

It has been demonstrated in numerous researches that integrating science process skills into Biology instruction can enhance student progress. For instance, a study by (L'Heureux, 2021) indicated that students who got instruction that was centered on developing science process skills in Biology outperformed those who received conventional instruction. Similarly, it was discovered that students' achievement in Biology improved more for those who were taught using inquiry-based techniques, which place an emphasis on science process abilities.

Researchers Mims, Lee and Kuldell, (2025) in their various studies highlighted the usefulness of various SPSs as follows: observation skills in teaching Biology as they allow students to gather data and make inferences about the natural world. Thus, improving observation skills in Biology students leads to improved test scores on content-specific assessments; teaching hypothesis formation skills in the context of Biology assists learners to becoming effective problem solvers in the natural world and consequently leads to improved students' learning outcomes; Experiment design skills allow students to test hypotheses and make data-driven conclusions. Experiment design skills therefore leads improved student understanding of scientific concepts; Analysis and interpretation data are critical skills in Biology, and students who develop these skills can become more effective at drawing conclusions

from scientific investigations; incorporating measurement skills in teaching Biology is important as it leads to improved students' understanding of scientific concepts and their ability to apply those concepts to real-world happenings; strong prediction skills assists learners to be more effective at designing experiments and interpreting data. Prediction skills in the context of Biology lead to improved student performance on assessments and greater confidence in their ability to solve scientific problems.

Gizaw & Sorsa (2023), in their literature review study, found out that Biology curriculum guidelines do not bring out the Science Process Skills but rather emphasize on the content of Biology as a body of knowledge and facts. It is imperative therefore that curriculum guidelines such as the syllabus, the teachers' guides and the students' course books do emphasize on the acquisition of science process skills so that learners can understand Biology as a way of life. Teachers should also explicitly help students acquire the SPS during the teaching and learning process. Even though these studies acknowledge that science process skills stimulate learning, little research has been done on the extent to which attainment of SPS affects achievement of learning outcomes.

In the application of Biology curriculum into everyday life context, appreciating the nature of science in teaching Biology is vital. Studies have indicated that Biology content knowledge in curricula guidelines ignores the nature of science (Juniar, Fardilah, & Tambunan, 2021). Indeed, these findings are pessimistic as other studies have shown that students who interact with a curriculum which appreciates the nature of science gain more from the classroom and laboratory experiences and learn Biology better (Superfine, Ko, & Goldman, 2022). For instance, the aspect of the

nature of science which states that science knowledge is 'subject to change' may facilitate understanding of Biology knowledge production. According to Gatica (2024), Biology curriculum should draw on examples that demonstrate changes in theories. Teaching of Biology by separating theories from laws and linking it to real happenings is what may bring comprehension and application of Biology in real life.

According to a study by Chatzikyriakidou, Tacloban, Concepcion, and McCartney (2022), teaching Biology as a tentative science-one in which concepts and hypotheses are frequently revised in light of fresh data-improved students' comprehension of Biology and greater engagement in science as opposed to learners who were taught depicting Biology as a static and unchanging science. Portraying Biology as unchanging can result in misconceptions and less accurate understandings of the subject. Nizomova (2023), in another study, discovered that employing imagination and creativity in Biology lessons improved students' understanding of scientific topics. According to the researchers, students can better understand abstract scientific topics by connecting them to real-world scenarios through the use of imaginative scenarios.

Another study by Toh & Zaidatun (2024) indicated that most Biology content curriculum guidelines ignore that the Nature of Science (NoS) matters in the application of Biology curriculum into everyday life context. The study states that the curriculum guidelines do not provide compelling rationales for or meaningfully promote intention to application of Biology Content knowledge into everyday life context. This shows that many curriculum developers ignore application of Biology Content knowledge into everyday life context. The study further notes that even the science laboratories in most schools fail to connect Biology to everyday life. This

finding indeed is disappointing as learning in the laboratory promotes experiments that can link Biology to real life hence promoting understanding of Biology among learners. Studies have however done little investigation on the extent to which appreciating the nature of science affects the achievement of learning outcomes among learners.

Biology researchers recognize the negative implications of doing Biology in a vacuum, devoid of social context which is an aspect of the nature of science. Social context means that in as much as empirical data derives the development of explanations in Biology, the society has a critical role in shaping how the study of Biology is done. Besides, it is also important to remember that Biologists are human beings who can develop biases (Boudry & Pigliucci, 2018). These views on society therefore should include everyday ways of knowing and teaching Biology. Boudry & Pigliucci's 2018 study noted that Biology is often taught as some facts and truths that are not part of the society. Studies have however not assessed the extent to which linking Biology into the social context may affect the achievement of learning outcomes.

2.4 Pedagogical Techniques and Learning Outcomes

Methods and techniques employed during the teaching and learning process influence achievement of learning outcome (Schilbert & Scheersoi, 2022)s. In other words, the way in which the subject matter is presented to learners determines the extent to which the learning outcomes are achieved. A study by Clark and Hsu (2023) carried out in the USA, compared the impact of an active teaching approach and a traditional (or passive) teaching style on student cognitive outcomes. One class was taught in an active or “nontraditional” manner, with a variety of active learning

exercises. The second class was taught in a passive or “conventional” manner, stressing on daily lectures. Although the active learning approach does not appear to have improved overall mastery of the subject, there was evidence that active learning led to improved cognitive outcomes in class-specific materials. The delivery style is therefore important on influencing the achievement of learning outcomes.

Another research study by Vincent-Lancrin, Vidal, & Yu (2023) carried out in the USA explored the relationship between passive learning methods, such as traditional lectures, and long-term retention of mathematical concepts among high school students. Through a longitudinal study spanning an academic year, the researchers compared the retention rates of students exposed to passive learning with those engaged in more active learning approaches. Findings revealed a substantial decline in long-term retention among students relying on passive learning methods. Implications for instructional practices and curriculum development should therefore emphasize active pedagogies in teaching and learning.

In another study by KNEC, (2022) in Kenya, it was noted that passive instruction is designed to promote student rote learning; just requiring learners to remember concepts. On the other hand, active learning such as problem-based instruction is an effective approach for teaching higher-level thinking processes requiring learners to evaluate and synthesize knowledge since it promotes inquiry learning and hence helps students construct their own knowledge. These findings imply that any approach used in teaching and learning and which puts the learner at the center of the processes promotes attainment of higher order skills. These studies have however not shown the kind of learning outcomes promoted by different learning approaches.

In India, a study by Filmer, Molina, & Wane, (2020) on teaching and learning approaches in science subjects, it was noted that cooperative learning and the problem-based approach informed by constructivist theorists increases achievement of student's learning outcomes in science subjects more than traditional teaching and learning approaches. The constructivist-instructed students had significantly higher scores compared to those instructed with teacher centered methods. Thus, constructivist methods and techniques of leaning should be the heart of teaching Biology as a science. These studies however do not specify the kind of learning outcomes achieved by constructivist learning approaches.

Another study carried out by Mandasari, Iwan, & Damopolii, (2021) examined learners' academic achievement on homogeneous examinations for two groups of learners for comparison. One group received highly structured active learning pedagogy and the other group received outdated, unstructured, lecture pedagogy. Results showed that students exposed to a highly structured, active learning pedagogy scored statistically significantly higher than students who received passive pedagogy. Results further showed that while increased active learning improved outcomes generally for all students who received it, those students at the lowest academic achievement levels experienced the most gains. These results therefore show that use of active pedagogy enhances the achievement of learning outcomes and more especially the weak students academically.

More studies that support active instructional pedagogies include the study by Felder & Brent, (2020) which investigated the effects of active learning strategies on student engagement and academic performance in a university-level Biology course. Utilizing a mixed-methods approach, survey data, and performance assessments, the

researchers compared the outcomes of an active learning intervention with a traditional lecture-based approach. Results indicated a significant increase in student engagement and a notable improvement in academic performance in the active learning group. This study, like most of the studies discussed, do not show the type of learning outcomes attained by use of different pedagogies.

A study by Filmer, Molina & Wane (2020) agrees with other studies reviewed earlier that pedagogical techniques encouraging active learning are to be embraced in teaching Biology but explains very little of the variation in learning outcomes. Mbatia et al (2020) in their study espouse that, in Kenya, contrary to the recommended active learning pedagogy, teacher centered methods of instruction, especially the lecture method, dominate science classroom practices. Mbatia et al (2020) warn that teacher centered methods often give a pseudo impression that effective learning has taken place as implied. The researchers argue that there is a difference when students are assessed on memorized material and when they are assessed on the application bit of the memorized material. This scenario of teaching science using passive pedagogical techniques despite serious warning by researchers should therefore be looked into. Findings on the kind of learning outcomes achieved by using active learning pedagogical techniques are yet to be documented by researchers.

2.5 ICT Integration and Learning Outcomes

Research has shown that, utilization of Information, Communication Technology (ICT) in the delivery of instruction has a huge positive impact on learning outcomes. However, studies carried out in Kenya showed that ICT integration was minimal in most schools in Rachuonyo South Sub County in Kenya (Otianga, 2020). This

finding is discouraging given that ICT integration is likely to lead to improvement in achievement of learning outcomes.

Research carried out in Zimbabwe identified the factors that were hindering the ICT utilization as lack of power supply, insufficient resources, fear of technology, lack of interest, ICT skills deficiency, higher ICT cost and poor physical infrastructure (Admire & Patience, 2024). Similarly, a study by Ergado, Desta, & Mehta, (2022) conducted in Ethiopia on ICT integration in teaching and learning noted that some of the critical factors preventing ICT integration were: lack of proper access to ICT resources, insufficient technical and pedagogical support. These findings show that the challenges preventing ICT integration are yet to be addressed.

Another study by Otianga (2020) in Kenya similarly showed that there is minimal ICT integration in teaching. The lack of use of ICT was attributed to inadequate number of computers and lack of sufficient training of teachers. Studies reviewed have shown that ICT integration may lead to high achievement of learning outcomes but little investigations have been done on the extent to which ICT integration influences the achievement of learning outcomes.

Admire & Patience, (2024) document about a study done in Zimbabwe whose aim was to assess the availability and utilization of ICT resources in secondary schools. The findings revealed that most of the ICT resources required for teaching and learning were missing in the sampled schools, and those that were available were inadequate. The findings further revealed that the available ICT resources were utilized to a very low extent. These findings show that ICT integration which is hoped to increase achievement of learning outcomes is yet to be achieved.

Despite minimal use of ICT integration, studies have shown that ICT integration has contributed a great deal towards the achievement of learning outcomes. A study by Fernandes, Rodrigues, & Ferreira, (2019) demonstrated that ICT simulations significantly improved student's academic student in Biology compared to traditional teaching method. Simulations allow students to visualize complex biological concepts, making them more accessible and engaging. These tools provide interactive experiences that promote exploration and understanding. A study by Otieno, (2022) carried out in Kenya however showed that ICT integration was minimal in most schools in Rachuonyo South Sub County in Kenya. This finding is discouraging given that ICT integration is likely to lead to improvement in achievement of learning outcomes.

Another study by Karunakaran & Dhanawardana, (2023) in India, which aimed at identifying the level of ICT integration in teaching and learning process in the classroom, showed that most of the teachers use ICT in the teachers' room for their own work rather than implementing it in the classroom for teaching and learning. The results further showed that provision of ICT-based learning opportunities for students improve their learning quality. Similar findings in another study by Rind et al (2022) which investigated the effects of ICT integration on the students' academic achievement and retention in chemistry showed that information and communication technology positively affects students' academic achievement and retention when contrasted with conventional techniques of teaching.

In Pakistan, a study by Nayab et al, (2021) evaluated the use of Information and Communication Technologies (ICT)-based initiatives on students' academic achievements in terms of students' science scores. The results showed that ICT use

has a positive as well as statistically significant impact on students' science learning. The results of the study also showed that students' level of interest toward learning science was enhanced by the use of ICT.

2.6 Summary of Literature Review

The main focus of the studies that have been reviewed in this chapter is on: the utilization of teaching and learning resources; the application of Biology content knowledge into everyday life context; the use of pedagogical techniques and the ICT integration. The most common research methods used in these studies were survey and quasi-experimental designs. The common methods of data collection in these studies were observation techniques, focused and in-depth interviews, use of questionnaires, and document analysis. Data analysis in these studies is mainly means, standard deviations and inferential statistics. Results from these studies have shown discrepancies in the teaching of Biology in: the utilization of teaching and learning resources; the use of pedagogical techniques; the application of Biology content knowledge into everyday life and the ICT integration. The main gaps identified in the studies reviewed are insufficient investigation on the particular learning outcomes improved due to effective Utilization of teaching and learning resources; use of pedagogical techniques; the ICT integration and; the application of Biology content knowledge into everyday life. Methods, findings and suggestions made in the reviewed studies shall inform this study. In addition, this study by use of qualitative research will go a notch higher to investigate the kind of learning outcomes improved by the four aspects of teaching Biology tackled in this study. Table 2.1 shows a summary of literature reviewed in this study.

Table 2.1: Summary of Literature Review

Study	Aim of study	Methods used	Findings	Gaps identified	How this study fills the gap
Nurhasanah, Handoyo, Widiyatmoko, & Rusdarti (2025) in Indonesia	To develop issue-based teaching materials to improve the students' learning outcomes	Three phases of the 4D model developed by Thiagarajan, namely define, design, and development.	-Utilization of teaching and learning resources achieves systematic and effective learning.	- Only material resources were developed and investigated. -The kind of learning outcomes were not established.	-This study investigated the use of material resources, and infrastructure - This study established the kind of learning outcomes enhanced by different resources.
Ong'amo, Ondigi and Omariba (2017) in Kenya.	To establish the effects of utilization of Biology teaching and learning resources on student academic performance	Survey design was used. The data was collected using questionnaires, observation schedules, checklists, and interview guides.	Students taught using teaching and learning aids performed better than those taught without the resources	The study does not establish which kind of learning outcomes were achieved with each particular teaching and learning resource.	This study categorized the learning outcomes achieved by use of different learning resources.
Christ, Arya and Chiu (2018) in China	To investigate the effect of digital resources on learning outcomes.	Survey design	Use of digital materials such as videos were best in application learning.	Does not show the kind of learning outcomes achieved by use of digital resources.	This study investigated the kind of learning outcomes achieved by digital resources.
Mwamba and	To find out the influence	A mixed method	Infrastructure had no	The study failed to	This study portrayed the

Study	Aim of study	Methods used	Findings	Gaps identified	How this study fills the gap
Kabungu (2018) in Zambia	of infrastructure such as laboratories on learner academic achievement	paradigm of an embedded method and descriptive survey design.	significant effect on learner academic achievement	point out other roles infrastructure plays in the learning process	role of infrastructure in the learning process.
Mwanda, Odundo, Midigo and Mwanda (2016) in Kenya	To establish the influence of instructional methods and learning achievement in different class categories.	Quasi-experimental Non-equivalent groups with a pre-test and a post-test.	All the learners especially girls instructed through the constructivist approach registered marked improvement in achievement	Achievement of specific learning outcomes are not investigate	This study investigated the kind of learning outcomes improved by constructivist approach.
Mwanda, Odundo and Midigo (2017) in Kenya	To investigate the attitude of learners towards the constructivist instructional approach and ICT integration	cross-sectional survey technique	-Learners have positive attitude towards the constructivist instructional approach -ICT integration improves learner participation.	Does not investigate if ICT integration improves achievement of learning outcomes.	This study investigated whether ICT integration improves learning outcomes and which learning outcomes in particular.
Boudry and Pigluicci (2018)'s literature review	Analysis of appreciation of the nature of science in Biology curriculum guidelines	Content analysis design	-Biology curriculum guidelines typically communicate science as a body of facts, the nature of science is ignored.	-appreciation of the nature of science curriculum guidelines is ignored.	This study found out how the appreciation of the nature of science in curriculum guidelines influences learning outcomes.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter entails: the research design, the location of the study, the target population, the sampling and sampling procedures, the research instruments, the piloting of research instruments, the validity and reliability of research instruments, the data collection procedures and the data analysis plan.

3.2 Research Design

In this study, the researcher deployed a mixed-methods approach using the explanatory sequential design. The mixed-methods approach was selected because it can effectively draw from both qualitative and quantitative data in response to research questions (Cameron & Golenko, 2023). It provides for both breadth and depth such that while quantitative data explores numerically measurable and to what extent the research can cover, qualitative data explores the “why” and “how”. This way, the approach provides a wholesome view of the research problem. Mixed methods approach also sets out to minimize the limitations of both approaches when deployed in isolation. According to (Toyon, 2021), a mixed methods design is a pivotal strategy if one wants to attain a more complete and in-depth understanding of research problems/questions.

The research philosophy used in this study was Pragmatism. Pragmatism picks out the research question and selects the most suitable methods to offer realistic solutions instead of limiting the study to one viewpoint. It is one of the most popular philosophies for mixed-method-research. The researcher interacts with the immediate environment and uses methods that will attain practical results

The explanatory Sequential mixed method design was used in this research. This design involved a two-phase sequence in which the researcher collected quantitative data in the first phase, analyzed the results, and then used the results to plan (or build on to) the second, qualitative phase. The intent of the quantitative phase was to inform of quantities such as learning outcomes; types such as the teaching and learning resources; and processes such as the teaching and learning process. The quantitative results characteristically informed the types of participants to be purposefully selected for the qualitative phase and the types of questions that were asked of the participants so as to gather explanations to the quantitative data.

The intent of qualitative research in this study was to understand the process of teaching Biology and the product (the learning outcomes) of the process. The researcher followed up on the schools that were identified from the quantitative data analysis. The researcher observed Biology lessons in the selected schools and sought the informants' perspectives and meanings. Qualitative approach according to (Cameron & Golenko, 2023), focuses on understanding the process that is occurring as well as the product or outcome. Qualitative approach provides for intense investigation, bringing out detailed and holistic understanding of the questions under investigation.

Mixed methods type of research fronted challenges to the researcher such as the need for extensive data collection and the time-intensive nature of analyzing both qualitative and quantitative data. To this, the researcher designed a clear flow of research activities. The researcher also assigned enough time for data collection and data analysis to give credibility to the research approach and consequently the findings.

3.2.1 Variables

Biology teaching was the independent variable and its indicators were: the utilization of teaching and learning resources; the application of Biology curriculum into everyday life context; the use of pedagogical techniques and; the ICT integration. The dependent variable was the achievement of learning outcomes namely cognitive, affective and skill outcomes. Biology teaching determines the achievement of learning outcomes. In other words, the achievement of learning outcomes is dependent on how teaching of Biology is carried out.

3.2.2 Research Methodology

The study deployed a mixed method research approach using explanatory sequential design. This method allows the researcher to first collect the quantitative data, analyze, and then collect the qualitative data to explain the findings from the quantitative data (Toyon, 2021). The quantitative phase employed a survey by use of questionnaires. Once data was analyzed from the survey, a qualitative phase followed which utilized observations, in-depth interviews and Focused Group Discussions (FGDs). According to (Zhou & Wu, 2020) mixed methods, the researcher collects both quantitative and qualitative data for the purpose of understanding the research problem.

During the quantitative phase, the researcher circulated the questionnaire in google forms to the Biology teachers in Nairobi City County via the internet. Using internet survey has been approved by many researchers, being convenient in terms of saving on costs and in data analysis (Toyon, 2021). The questionnaire was used to collect all information about Biology teaching and learning according to the research objectives. The researcher analyzed the data collected and identified the areas to

follow up in the second qualitative phase. The results from the first phase also identified the schools that were followed up and involved in the second phase. According to (Cameron & Golenko, 2023) use of questionnaires is suitable in collecting large information within a short period of time and allowing for analysis of results by studying a sample of the population.

Different sampling strategies were done in this study's mixed-method approach so as to cater for both quantitative and qualitative elements. In a single school, identical sampling was used for both the qualitative and quantitative stage. The same sets of respondents were interrogated to attain both the qualitative and quantitative data. For all the schools at large, parallel sampling was used. The confidence here was that different respondents given similar research questions would still provide accurate results by virtue of experiencing similar environments. This is explored further under subheading 1.4.

The study targeted all the 114 public secondary schools in Nairobi County categorized as 6 national schools, 20 Extra County schools, 58 County schools and 20 Sub-County schools. The study also targeted 3 Biology specialists from CEMASTEPA, KU and KICD. In addition, the study targeted 228 Biology teachers and 5700 form three students. The total target population was therefore 5814.

For the qualitative phase, class observation guides were utilized to observe three lessons in each of the selected schools within a period of 12 weeks. The researcher observed the classroom lessons from the back of the classroom in order to get a clear view of what both the learners and the teachers will be engaged in as classroom activities. Also, the position aimed at avoiding any interruptions of the lessons from the researcher. After observations, the researcher further sought for clarifications

from observed documents and happenings from the concerned teachers and the students.

FGDs were used to get information from the students. The researcher probed for more information during the FGDs. So as to ensure that all the data and information captured in the first phase was clearly explained, the researcher recorded the discussion. However, prior to the recording, the researcher requested for informed consent. The researcher took notes of the discussions, including facial expressions and any reactions.

Interview guides were used on the selected Biology specialists. The researcher asked questions and probed for more information. She also recorded the interview proceedings after having requested for informed consent. Besides, she took notes during the interview as well as noted facial expressions and any unique happenings. According to Zhou & Wu, (2020) in-depth interviews, observations and focused group discussions are the main methods in qualitative research of case studies.

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3.3 Research Location

The study was conducted in Nairobi City County, Kenya. Nairobi City County was selected for this study because attainment of learning outcomes in Biology in Nairobi County has been below average since 2013 (see table 1.2). In addition, Nairobi County has a good representation of Kenya as a whole in the following ways 1) it is cosmopolitan, with people from all ethnic groups from all parts of Kenya 2) It has all categories of schools represented in Kenya; National, Extra county, County and Sub county 3) Schools in Nairobi County are situated in different areas of social economic status whereby there are schools in low income areas, middle income areas and high-income areas. This agrees with Kilal et al (2021), who state that a suitable location of study should be a good representation of the study variables.

3.4 Target Population

The study targeted all the 114 public secondary schools in Nairobi County categorized as 6 national schools, 20 Extra County schools, 58 County schools and 20 Sub County schools. The study also targeted 3 Biology specialists from CEMASTEIA, KU and KICD. In addition, the study targeted 228 Biology teachers and 5700 form three students. The total target population was therefore 5814.

Public schools were targeted because many students, about 70%, attend public secondary schools as compared to private schools, hence a good representation of students were in public schools. The Biology specialist from KICD was selected because KICD is responsible for developing curriculum guidelines while the Biology specialist from KU was selected because they are responsible for training teachers in content and pedagogical skills. A Biology specialist from CEMASTEIA was selected

since they organize In-Service Teacher Education Training (INSET) of Biology and other science teachers.

Biology teachers were targeted because they directly impart Biology knowledge, skills and attitudes to learners which is assessed to find out how much learning outcomes the learners have achieved. The Biology form three learners were targeted because they receive and interact with the Biology curriculum in their learning process. Particularly, form three learners were selected because at the time of data collection, they had covered more Biology content knowledge compared to form ones and twos. On the other hand, the form fours were preparing for their national examinations and were not fully available to take part in the study.

By studying the targeted population, therefore, the objectives of the study were likely to be achieved.

3.5 Sampling Procedures and Sample Size

For the quantitative phase, the researcher used single-stage sampling procedure using random sampling to identify 114 out of the 228 teachers of Biology. This gave a sample of 50% of the Biology teachers in Nairobi City County. The sample of 114 was arrived at by using Fowler's (2009) table cited in (Cameron & Golenko, 2023) with a margin of error of $\pm 4\%$, a confidence error of 95%, and a 50/50 chance that the sample contains the characteristics of the study. Single- stage sampling was suitable given that the researcher had access to names of school of the target population and could sample teachers directly. Simple random sampling was used because it is a method which gives an equal chance for all the participants to be selected for the study.

For the qualitative phase the researcher used purposive sampling. The sample that was selected was informed from the analysis of the quantitative phase. According to (Anand, Kanhe, Abirami, & Tiwary, 2025), purposive sampling is the most suitable procedure to use in qualitative research. It allows the user to select participants who have the required information for the study. Accordingly, the study selected six schools that had unique characteristics that needed to be followed up for more explanations. According to (Cameron & Golenko, 2023) for effective study, a sample of up to six is sufficient in qualitative approach.

From the selected schools, six teachers of Biology who teach form three class were sampled for class observation. From each of the six schools, 8 learners from form 3 were selected using purposive sampling to participate in Focused Group Discussions (FGD). The researcher requested for the assistance of the teachers in selecting the participants for the focused group discussions.

The sample also included three specialists of Biology from CEMASTEPA, KU and KICD who were selected purposively for in-depth interviews. Thus, the total sample population for the qualitative phase was six Biology teachers, 48 form three learners and three Biology specialists, making a total sample population of 58 sample participants. According to (Zhou & Wu, 2020), qualitative samples are usually small for practical reasons of generating and analyzing qualitative data. Table 3.1 gives a summary of the sample population.

Table 3.1: Sample size

Respondent category	Sample
Quantitative phase	
Teachers	114
Total	114
Qualitative phase	
Biology Specialists	3
Biology Teachers	6
Biology Learners	48
Total	57

Source: Researcher's own design

According to (Zhou & Wu, 2020), the sample comprises of the population that will serve the purpose of the study.

3.6 Research Instruments

The study utilised questionnaires for teachers to collect quantitative data. For qualitative data, the study utilized Interview guides for Biology specialists, FGDs for learners and class observation guides which were used by the researcher.

3.6.1 Questionnaires

Questionnaires sought information from teachers regarding the utilization of teaching and learning resources; the application of Biology curriculum to everyday life context; the use of pedagogical techniques and the ICT integration (see appendix D). The items in the questionnaire were close ended.

3.6.2 Interview Guides

The study used Interview guides for Biology specialists (see appendix II). The interview guides contained both semi structured items and open-ended items that

sought pertinent information on the utilization of teaching and learning resources; the application of Biology curriculum to everyday life context; the use of pedagogical techniques and; the ICT integration. The items allowed for probing so as to collect pertinent information regarding the action of teachers. (Zhou & Wu, 2020), notes that interview guides allow the researcher to collect in-depth information about the phenomenon. The interview guides for Biology teachers therefore, sought more information from teachers following class observations.

For all the specialists, the interview guides sought information regarding utilization of teaching and learning resources; the application of Biology curriculum to everyday life context; the use of pedagogical techniques and; the ICT integration. Interview guides for Biology specialists were tailored to specific specialists. For instance, interview guide for the KICD specialist had specific items seeking information about the Biology curriculum; for the specialists from CEMASTEPA and KU, there were specific items seeking information about preparation of Biology teachers. According to (Anand, Kanhe, Abirami, & Tiwary, 2025), interview guides allow the researcher to collect important information and to clarify an observed phenomenon from the respondent.

3.6.3 Focused Group Discussion (FGD) Guide

The study used a Focused Group Discussion (FGD) guide for learners. The focused group discussion guide sought information from learners of the selected schools regarding issues in Biology teaching identified from the analysis of the quantitative phase. These issues concerned teaching and learning materials, application of the Biology curriculum in everyday life context, pedagogical techniques during Biology teaching and ICT integration (see appendix III). 6-8 participants are sufficient for an

FGD (Toyon, 2021). In this study, eight Biology learners from each of the selected schools were selected to participate in the FGD within their schools. According to Zhou & Wu (2020), more than ten participants would be difficult for a researcher to control.

3.6.4 Class Observation Guide

The researcher used class observation guide to record the exact happenings in Biology classrooms (see appendix V). Observation guides help researchers to ascertain information given as well as other information which the respondents may leave out (Cameron & Golenko, 2023). According to Cameron and Golenko, class observation guides help the researcher to collect data in settings that are natural, give an opportunity for insightful data collection and are instant in follow-ups on change activities.

In this study, the observation guides closely examined the school factors, the Utilization of teaching and learning resources, the application of Biology content to everyday life and the use of pedagogy as well as the ICT integration. The observation guides also examined actions and facial expressions that indicated perceptions of both teachers and learners. (Tarusha & Gjuzi, 2024) point out that some of the fundamental purposes of classroom observations include describing the current status of instructional practices and also the extent to which technology is used in the classroom.

3.7 Piloting of Research Instruments

One public school was selected purposively for piloting. Before carrying out the pilot, respondents in the pilot school were made aware of the intended study and its purpose. The instruments were then tried in the pilot school. At the end of the study,

the data from the school that was used for piloting was excluded from the list of the final sample to give methodology credibility.

Piloting helps to test the appropriateness of the items as well as the time required to use each instrument. During and after piloting, the items were accordingly be improved to enhance their reliability and validity (Anand, Kanhe, Abirami, & Tiwary, 2025).

3.7.1 Validity of Research Instruments

In this study, the researcher used two strategies to ensure the validity of the research instruments. For the quantitative data, statistical method by Cronbach was used. Cronbach value of more than 0.8 indicated that the items were reliable for the study. Izah, Sylva, & Hait (2024) indicated that Cronbach correlation is a suitable method for determining the validity of quantifiable items. For qualitative instruments, the items in the interview guides, the FGD guides, the document analysis guide and the lesson observation guide were triangulated to ascertain validity. Triangulation helped the researcher build a coherent justification of themes. Researchers recommend triangulation in qualitative research as a suitable method to ensure validity (Cameron & Golenko, 2023).

3.7.2 Reliability of Research Instruments

To ensure consistency in responses, the research instruments were tested and retested to assess the clarity and suitability of the language used and ensured that they were reliable before the actual study was carried out. According to Cameron & Golenko (2023), test and retest is a suitable method of ensuring reliability of instruments in a qualitative research.

3.8 Data Collection Procedures

Prior to embarking on collection of data, the researcher applied for permission from the National Commission of Science, Technology & Innovation (NACOSTI) to conduct the research. Once permission was granted, the researcher liaised with the County Director of Education (CDE) and briefed her about the intended research. The CDE wrote a letter of clearance for research within the County and then linked the researcher to the Sub County Directors of Education (SCDEs) and briefed them about the intended research. The Sub County Directors of Education (SCDEs) then introduced the researcher to the principals of the sampled schools. The researcher, upon introducing the study to the principals, requested them to introduce her to the HODs and the Biology teachers. The researcher then circulated the questionnaires to the teachers via the internet. Upon collecting data from the questionnaires and analyzing it, the researcher selected six schools with unique findings that were informed from the analysis of the questionnaire.

The researcher then visited the selected schools for further data collection for the qualitative phase. The researcher, with the help of the HODs and the selected Biology teachers, arranged when the Biology lessons were to be observed. The researcher and the selected Biology teachers organised for a group of eight students from the selected class to participate in a focused group discussion. A timetable of events during the study was developed by the researcher in consultation with the various Biology teachers and Biology specialists involved in the study.

After collecting data from the schools, the researcher visited three identified Biology education specialists from CEMASTE, KU, and KICD and organized on when she

could carry out interviews with them. Respective dates of the interviews were followed and interviews done as agreed with the Biology specialists.

3.9 Data Analysis Plan

Quantitative data in the questionnaire from the first phase of research was assigned numbers or symbols using a code book to simplify the data for analysis. The data was then be entered in a Statistical Package of Social Science (SPSS) for analysis. Descriptive statistics was used to analyze quantitative data which included frequencies, and means. The findings were expected to have a margin of error of +/- 4%, and a confidence error of 95%. The data was analyzed according to the objectives of the study.

Qualitative data that was obtained from class observation notes and interview guides and from the curricular guidelines was grouped into categories and themes and analyzed as per the objectives of the study. A rich description to convey the findings was done. The researcher also portrayed more than one perspective of the themes. This description was intended to take the readers to the natural setting and give the findings an element of shared experiences. According to Zhou & Wu (2020), detailed descriptions offer many perspectives about a theme, making the results more realistic and richer. The qualitative data sought for explanations raised from the analyzed quantitative data. The modes of presentation of the findings were as per objectives of the study. Table 3.2 shows the summary of the data analysis plan.

Table 3.2: Summary of Data Analysis Plan

Objective	Data collection tool	Data analysis plan	Data presentation
Utilization of teaching and learning resources and achievement of learning outcomes	-Questionnaire guide for Biology teachers -Lesson observation guides -Interview guide for Biology specialists -Learner FGDs	Data collected from interview guides, FGDs and from lesson observation notes was grouped into themes and analyzed vis-à-vis learner outcome tests	Frequency tables Detailed Description.
Application of Biology content knowledge into everyday context and achievement of learning outcomes	-Learner FGDs -Lesson observation guides -Questionnaire for Biology teachers Interview guide for Biology specialists	Frequency of the appearance of the themes in curricula guidelines was noted and analysed vis-à-vis learner outcome tests. Data collected from interview guides, FGDs and from lesson observation notes was grouped into themes and analyzed vis-à-vis learner outcome tests	Frequency Tables Detailed Description
Use of pedagogical techniques and achievement of learning outcomes	-Questionnaire for Biology teachers -Lesson observation guides -Interview guide for Biology specialists -Learner FGDs	Data collected from interview guides, FGDs and from lesson observation notes was grouped into themes and analyzed vis-à-vis learner outcome tests	Frequency Tables Detailed Description.
ICT integration and achievement of learning outcomes	-Questionnaire Biology teachers -Lesson observation guides -Interview guide for Biology specialists -Learner FGDs	- Data collected from interview guides, FGDs and from lesson observation notes was grouped into themes and analyzed vis-à-vis learner outcome tests	Frequency Tables Detailed Description

3.10 Logistical and Ethical Considerations

The researcher sought for permission to conduct the research from the National Commission for Science and Technology & Innovation (NACOSTI). This was upon clearance from the University. Once permission was granted, the researcher made a formal visit to the County Director of Education (CDE) and obtained the research authorization. The benefits of the research of both the researcher and the participants were communicated to the respondents. Once the concerned participants agreed to be part of the study, the researcher sought their consent before beginning to collect the data, especially in recording the information during the happenings of the interviews and FGDs. The respondents were informed that they could stop the interview or FGD at any point if they did not want to proceed. The researcher observed utmost confidentiality and anonymity throughout the study. The study's findings were shared with the participants at the end of the study.

CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the findings, interpretation and discussion of findings. The researcher sought to analyze and interpret quantitative data first, and use the findings to seek explanations from the analysis of the qualitative data. Under each objective, the researcher seeks to find out if both sets of data are consistent with each other, and if not, up to what extent. The researcher intends to portray that the qualitative data explains quantitative data or vice versa. Likewise, the researcher sets out to identify areas, if any, where there is complete divergence between the two data sets.

This study investigated the teaching and learning of Biology and its influence on learning outcomes. The objectives of the study were to:

- i. Assess the utilization of teaching and learning resources in Biology and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County
- ii. Evaluate the application of Biology curriculum in everyday life context and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- iii. Assess the pedagogical techniques used in Biology teaching and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- iv. Examine the integration of ICT in Biology teaching and its influence in the achievement of learning outcomes in public secondary schools in Nairobi County.

4.2 General and Demographic Information

4.2.1 Return Rate

The response rate of the questionnaire used for the quantitative survey part of the study was 100 out of the expected 114 teachers. This was a return rate of 88%. Kihal, Nurullayev, Schulze, & Skiera (2021) indicate that a return rate of 55% and above is acceptable.

4.2.2 Demographic and Background Information of Respondents

The respondents targeted in this study were Biology teachers, form 3 Biology students from selected schools and Biology specialists from: Kenya Institute of Curriculum Development (KICD), Centre for Mathematics, Science and Technology Education Africa (CEMASTEIA), and Kenyatta University (KU). The Biology teachers responded to the study questionnaire, the Biology students participated in focused group discussions (FGDs), while the Biology specialists participated in interviews as key informants.

The demographic data of the teachers who participated in the survey included gender, age, qualification and years of experience. The gender of the Biology teachers who participated in the study was 52% male and 48% female, showing that there could be more male teachers of Biology than female teachers in Nairobi City County. This finding shows that the negative gender stereotype that science subjects like Biology are the preserve for men while women go for languages and humanities persists (Admire & Patience, 2024). One can therefore argue that whereas there has been progress in reducing gender inequalities in participation of female teachers in Biology, the participation of female teachers in Biology is still a subject of concern

and more effort combined with innovative strategies need to be pursued to address this concern.

The ages of the Biology teachers who participated in the study are as shown in table 4.1

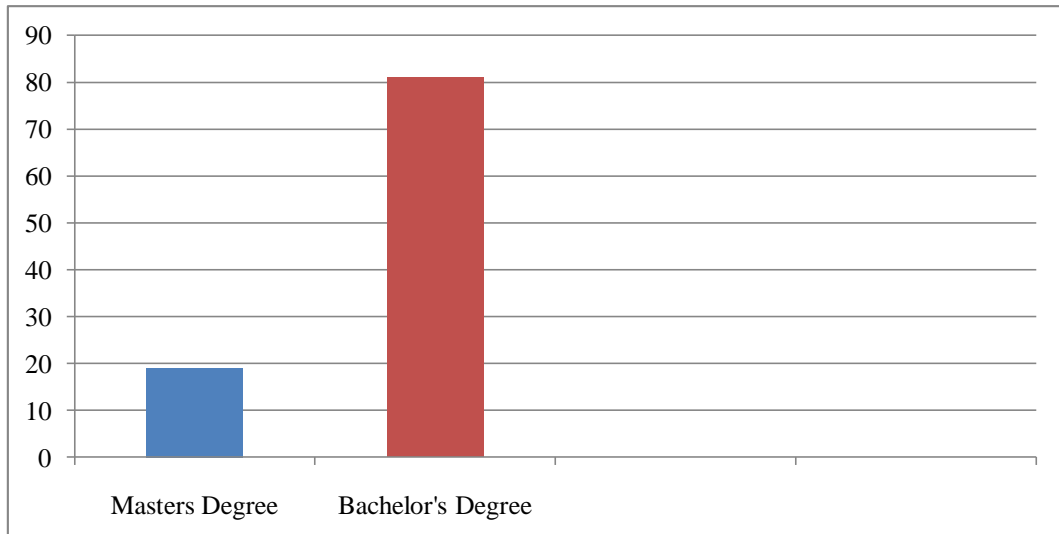
Table 4.1: Age Distribution of Teachers who participated in the Study

Age	Frequency (F)	%
20-24	0	0
25-34	48	48
35-44	24	24
45-54	22	22
Above 55	6	6
Total	100	100

Nearly half of the Biology teachers (48 out of 100; 48%) who participated in the study were between the ages of 25 and 34. Some of the teachers (24 out of 100; 24%) were aged between 35 and 44 while some others (22 out of 100; 22%) were aged between 45 and 54. A few (6 out of 100; 6%) were aged above 55. These findings show that many Biology teachers (72 out of 100; 72%) in Nairobi are aged between 25-44, implying that they are fairly young and seemingly energetic hence more likely to teach better and are acceptable to the students. These findings agree with Bwalya (2023) who note that many students prefer younger teachers to older ones. One can therefore argue that ages of Biology teachers being youthful in Nairobi City County, it is a favorable factor and may positively influence the participation of Biology learners

The qualification of the Biology teachers who participated in the study is as shown in figure 4.1.

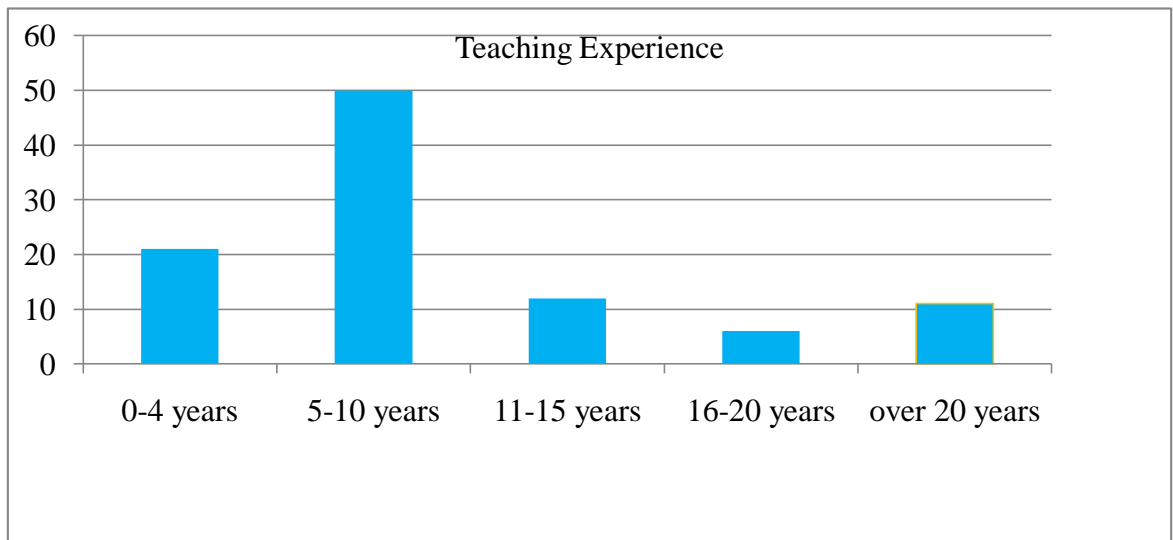
Figure 4.1: Teacher Qualification



The qualification of Biology teachers was either a Bachelor's or Master's degree. Most of the teachers (81%) were Bachelor's degree holders while the remaining (19%) were Master's holders. These findings show that all the Biology teachers who participated in the study were above the minimum qualification needed of secondary school teachers which is a diploma (Gichuhi, 2025). These findings show that Biology teachers were well qualified. It was thus expected that they were able to teach the Biology subject in accordance with the standards as per the curriculum guidelines.

The teachers who took part in the study were asked to indicate the number of years they have taught Biology. The teaching experience of the teachers who participated in the study is as shown in figure 4.2.

Figure 4.2: Teaching Experience in Years for Teachers who participated in the Study



Half of the teachers (50 out of 100; 50%) had a teaching experience of 5 to 10 years. Approximately 17% of the respondents (17 out of 100) had a teaching experience of less than 4 years. Of the total 100 respondents, 12 % had an experience of 11 to 15 years, a similar figure to the teachers who reported to have an experience of over 30 years. The remaining 9 respondents (9%) had a teaching experience of 16 to 20 years. According to the findings, majority of the teachers (83%) had a teaching experience of more than 5 years. A study by NyasakaOrina, Koros, & Ndanu (2022) found that the teachers' effectiveness, as measured by student test scores, tends to increase with years of teaching, with the largest gains seen in the first three to five years. The current study finding therefore suggests that most of the teachers had the required experience to positively influence learning outcomes of the Biology students.

The demographic information of the three key informants focused on age and work experience. Key informant W was aged 56 and had a work experience of 25 years. Key informant X was aged 60 and had a work experience of 30 years. On the other hand, key informant Y was aged 42 and had a work experience of 5 years in the current position. Key informants with an experience of more than 5 years relate to the areas of their expertise and professional roles in giving information (KNEC, Competency Based Assessment Framework, 2021). One can therefore argue that the key informants who participated in the study had the recommended experience of between 5-30 years and would therefore give reliable information to the study.

4.3 Utilization of Teaching and Learning Resources

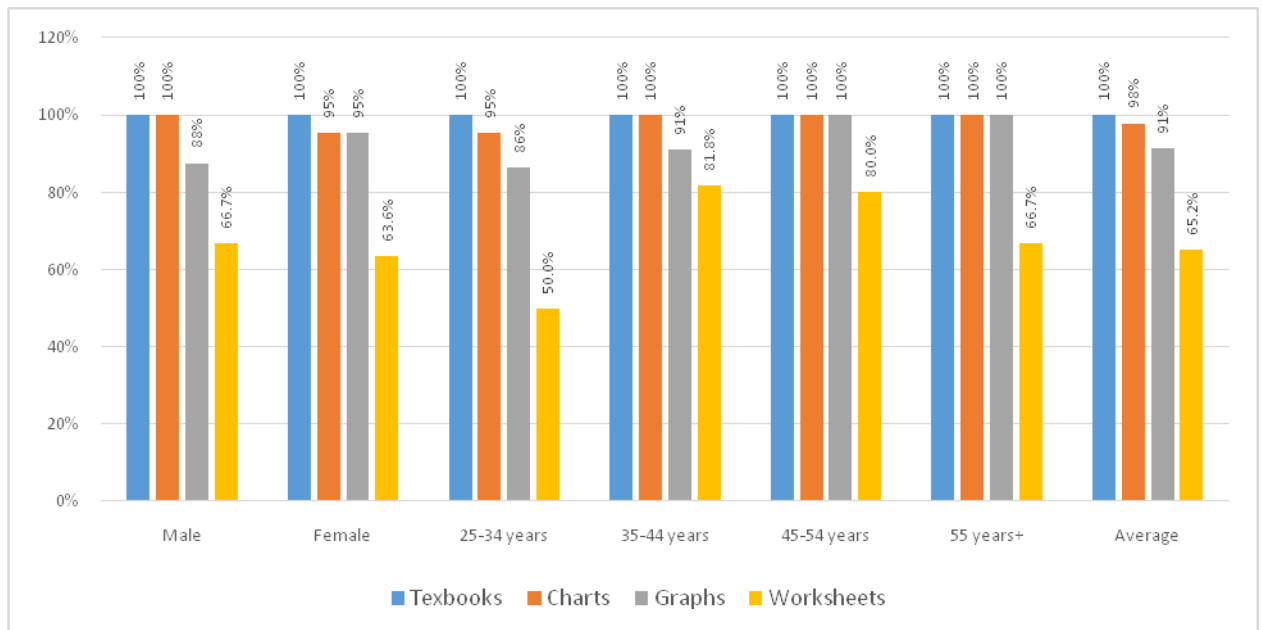
The first objective was to assess the utilization of teaching and learning resources in Biology and its influence on the achievement of learning outcomes. The study analyzed the utilization of two types of learning resources namely: material and infrastructure.

4.3.1 Use of Material Resources

Findings from the Quantitative Study on use of Material Resources

In the quantitative study, the teachers who participated in the survey were asked to indicate whether they used various material resources in the teaching of Biology. Figure 4.3 shows the responses of Biology teachers on the use of material resources.

Figure 4.3: Use of Material Resources in Teaching Biology



All the 100 teachers (100%) who participated in the study across the ages and gender stated that they used textbooks in teaching Biology. Majority, 98 teachers (98%) of who participated in the study used charts while 91 teachers (91%) used graphs. Worksheets were the least popular with only 65 teachers (65%) indicating that they used them. These results point out that teachers utilized material resources to a large extent (ranging between 65% and 100%) in the teaching of Biology. These findings agree with UNICEF (2022) findings, which indicated that material resources, especially textbooks, are common because they are available and easy to use. One can therefore argue that teachers tend to use only readily available and easy to use resources, and may not go the extra mile to find other relevant unavailable resources. In this study, it was highly likely that textbooks were the most available and easy to use, followed by graphs and then charts, while the least were the worksheets. According to AlAfnan (2025), Biology teachers use charts and graphs to enhance the understanding of learners of biological concepts through visualization, enhancing memory of lessons taught. Thus, the findings of this study show that Biology

teachers made attempt to enhance learners' memory of biological concepts as evidenced by over 90% teachers who reported to have used graphs and charts.

After establishing the utilization of material resources in Biology teaching, the researcher assessed the influence the use of material resources had on achievement of learning outcomes. From the quantitative study, and on a scale of 1-5 (1- lowest 5- highest), the researcher established from the Biology teachers the extent to which different material resources contributed to achievement of learning outcomes. Table 4.2 shows the responses.

Table 4.2: Extent to which Material Resources Contribute to Learning Outcomes

Teacher Characteristics		Textbooks	Charts	Graphs	Worksheets
Gender	Male	4.21	3.83	4.04	3.17
	Female	3.91	3.50	3.41	3.32
Age	25-34 years	3.77	3.50	3.50	3.05
	35-44 years	4.27	4.18	3.82	2.91
	45-54 years	4.70	3.70	4.40	3.90
Experience	55 years+	3.33	3.00	3.00	3.67
	4 years or less	3.25	3.50	3.38	3.13
	5-10 years	4.22	3.78	3.70	3.17
	11-15 years	4.40	4.20	4.00	2.60
	16-20 years	4.00	2.00	4.00	4.00
	21-25 years	4.75	4.50	4.50	3.75
	30 years and above	3.80	2.60	3.60	3.80
Average		4.07	3.67	3.74	3.24

The teachers across all the ages, genders and years of teaching experience who participated in the study, on average, on a scale of 1-5 rated worksheets, charts and worksheets as somewhat useful (3.24, 3.67, 3.74 respectively) in enhancing the achievement of learning outcomes. Use of textbooks was rated as considerably useful (4.07) in enhancing learning outcomes. Most teachers therefore noted that among material resources, textbooks were the most effective in the achievement of learning outcomes. This was contrary to other researchers, for instance (KNEC, Competency Based Assessment Framework, 2021), who state that use of textbooks encourages memorization and rote learning which doesn't allow for a deeper understanding of a subject. This finding implies that in this study most Biology teachers' way of teaching did not promote higher levels of comprehension hence most likely leading to low achievement of learning outcomes by learners.

According to KNEC reports of 2013-2022, most Biology students fail questions which require high cognitive outcomes such as analysis and evaluation. Teachers with a long teaching experience (30 years and above) however rated worksheets the highest among the four material resources in influencing high achievement of learning outcomes. These findings agree with researcher Buffalari (2022) who indicated that using worksheets can promote active learning and help students understand biological concepts as well as improve students' critical thinking abilities. Active learning helps learners to process information and forge deeper understanding hence better achievement of learning outcomes. In this study, however, use of worksheets was minimal hence a likelihood of less achievement of learning outcomes.

Findings from the Qualitative Study on use of Material Resources

The researcher sought to find out from the experts how teachers and students should use material resources especially the textbooks. The researcher asked the key informants (KI) a question whose responses were as follows:

How should teachers utilize textbooks in Biology teaching to enhance learning outcomes?

KIW

When it comes to books, we tell teachers how to study the books they use because there is also a case where teachers teach the text book and not the curriculum... some teachers have never looked at the syllabus. Some teacher wakes up and looks at the topic in the textbook and makes notes.

On the same concern of how teachers should utilize textbooks, Key informant Y added:

How should teachers utilize textbooks in Biology teaching to enhance learning outcomes?

KIY

KICD has prepared the 'orange book' which has specified a list of books you are to select from. Like we have the longhorn, the comprehensive, we have the oxford. So, a teacher is not supposed to just use one particular book.

The key informants advised that the textbooks should be used in line with the syllabus and that it should be identified from the list of approved books by KICD in the 'orange book'. The advice by the key informants on use of textbooks rhymes with researchers NyasakaOrina, Koros, & Ndanu (2022) who indicate that textbooks being an essential tool in teaching, teachers should use them as per the curriculum guidelines. From the findings of the present study, one can advise that the teachers need to analyze the syllabus so that they understand what the curriculum requires before they use the text book. Teachers should teach according to the syllabus and not according to the text book as many teachers seem to. Biology teachers should therefore avoid overreliance on textbooks while teaching and instead prepare adequately as per the curriculum guidelines. This is important because if the text

book in use is not well authored as per the syllabus then the students may miss out important knowledge and skills.

Additionally, Biology teachers should consult the 'orange' book where books approved by KICD are listed. Such books will most likely be suitable because they undergo a rigorous process before approval hence likely to contain no or fewer errors. Also, it can be suggested that teachers may refer to more than one text book. This is to help them compare information, and should there be any erroneous information, they are able to help students detect and hence get the correct information.

The researcher followed up in six different schools and asked students in an FGD how their teachers and themselves utilized textbooks in the learning of Biology. The responses from the learners were as follows:

FGD question: *How do you and your Biology teacher utilize material resources like textbooks, charts, worksheets and graphs during Biology teaching and learning?*

School Q

R1: We refer to different types of textbooks. Highflier, test it and fix it, get it right, KCSE made familiar...

R2: The teacher comes with his own notes from the website, from the media and research and we students have the government course book certificate and other revision books so we check different points from every section.

R3: Sometimes the text book can help for revision. We have more revision books compared to course books.

R3: Some textbooks however have computer errors which may mislead the learner.

R4: Some textbooks have too many notes that can make a student not to read all of them.

R5: Our teacher also uses charts to show diagrams though not often

R1: Once in a while he also uses worksheets and asks us to work in pairs or groups.

In school Q, the students used textbooks for reference and revision. School Q learners indicated that they read a variety of books on their own and compared the books. The use of material resources in schools R, S and T was more or less similar to school Q. This means that in school Q, R, S and T, students had access to more than one text book for use and this is a pointer to better learning. The findings on use of textbooks concur with those of (NyasakaOrina, Koros, & Ndanu, 2022) who found that textbooks were the main material resources used in Biology teaching because they provided a systematic presentation of content, providing diagrams and illustrations, and usually contain review activities and tests which enhance learning. The learners in school Q, since they referred to more than one book, pointed out that some books had typos while others were too wordy. This indicates that the learners used the textbooks keenly and were able to identify typos in different books. In addition to the available textbooks, the teacher in school Q prepared notes from other sources such as media and internet. From the findings of this study, it can be argued out that use of textbooks is unavoidable, therefore Biology textbooks need to be highly vetted and those with errors should not be allowed to reach the consumers.

The teachers in school Q used charts at times to show diagrams and worksheets once in a while for learners to work in pairs or in groups. This shows that charts and worksheets were less often used than textbooks. The findings on usage of charts, graphs and worksheets agree with (Buffalari, 2022) who note that even though work sheets, graphs and charts are useful material resources in teaching of Biology, they are less used as compared to textbooks. Given that the three resources are handy in the teaching of Biology, teachers should make a deliberate effort to utilize them to facilitate better learning among students.

Unlike learners in schools Q, R, S and T, learners in school V and U expressed challenges in utilization of textbooks and other material resources. Learners in school V had this to say:

FGD question:*How do you and your Biology teacher utilize material resources like textbooks, charts, worksheets and graphs during Biology teaching and learning?*

School Q

R1: We use 2 textbooks. KLB and certificate. Our school has few books because of lack of money to replace the lost ones by former students. The teacher usually uses KLB and students share few copies of certificate. Sometimes the information in the books is not the same. When the teacher asks a question and use certificate sometimes you are not getting it.

R2: We write our own notes from certificate.

R3: Our teacher doesn't use charts and worksheets. We use only the textbooks.

In school V, the learners used only two types of textbooks. The teacher asked them to write their own notes from a different book (Certificate) from the one s/he used (KLB). This shows that the learners copied a text book into their note books because of inadequacy of textbooks. These findings of inadequacy of textbooks in some schools agree with Mbatia, Wanjala, & Edome (2020)'s finding that the high cost of teaching and learning resources can be an impediment to utilization of material resources such as textbooks.

In this study, learners in school V had to copy notes from a text book. This must be time consuming leaving less time for students to comprehend the knowledge in the textbooks. The textbook that the learners preferred (KLB) was not accessible because it was only one and for the teacher. These findings where the one available preferred textbook was used by the teacher and not the student concur with (Gatica, 2024) who states that in schools that did not have adequate resources, the few that were available were mainly used by teachers and not the students. From the present study, because of lack of funds to purchase any other additional text book, they were

stuck to the available (Certificate) text book which they didn't prefer. The text book (Certificate) that the learners used was described as having errors. It looks like the book the teacher used was better than the one the students used in terms of quality but then there was only one copy which the teacher kept. This scenario in school V was disheartening given that findings in this study and other earlier studies show that textbooks are the main material resource used and yet in this study, in some schools like U and V, textbooks were not only inadequate but had errors. Further, the teacher in school V did not use charts and worksheets. This means that the teacher and the learners only relied on textbooks which unfortunately were insufficient. This most likely put the students in schools with same conditions as school V at a disadvantage in terms of learning.

The researcher in a qualitative approach sought to find out from the experts how the use of material resources such as textbooks, charts, graphs and worksheets influence achievement of teaching and learning resources according to Bloom's taxonomy. The order of cognitive learning outcomes according to Bloom's taxonomy from the lowest to the highest was originally divided into six levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. In 2001, this taxonomy was revised, to levels namely: remembering, understanding, applying, analyze, evaluate, synthesis. Key informant X had this to say:

KII Q: how does the use of material resources such as textbooks, charts, graphs and worksheets influence achievement of teaching and learning resources according to Bloom's taxonomy?

KI X

"You know Bloom's taxonomy starting from the lowest level of knowledge there are various things that are done. Using textbooks can help learners remember which is the lowest. It only requires a student to remember what they were taught. If the text book is good and has illustrations it may help learners to comprehend. Illustrations, charts and graphs help learners visualize hence comprehend concepts. When you use worksheets, especially

in groups, It helps learners work together. That is collaborative learning which encourages positive attitude. When one student is saying “si uangalie...” what are you seeing? that one promotes achievement of higher outcomes like application and analysis.”

Key informant X noted that use of textbooks promotes low order learning outcomes such as remembering concepts but if illustrated it may enhance comprehension. This means that students who over rely on textbooks are unlikely to achieve higher order learning outcomes. The informant further noted that use of charts and graphs help in visualization hence promote comprehension learning outcomes. Charts and graphs enhance fairly high order learning outcomes while worksheets enhance higher skills such as application and analysis, which are high order learning outcomes, because worksheets promote collaborative learning.

This information from the key informant is in sync with (Masu & Abe, 2025) who note that materials enhancing visualization in learning Biology such as charts and graphs can to a great extent promote students' comprehension of Biology. Worksheet resources can further assist students in understanding the material and applying concepts to fresh situations. The material resources that can enhance higher order learning outcomes can therefore be ranked as worksheets, followed by graphs and charts and the least being the textbooks.

The researcher further sought from the learners' FGDs what learning outcomes teaching and learning resources such as textbooks, graphs and charts helped learners to attain. The following were the responses from school Q:

FGD Q. What learning outcomes do we obtain from using textbooks, graphs and charts? school Q

R1: Text book can help one to improve on what the teacher has not taught but other classes have been taught and your class have not been taught so you refer and are able to remember.

R3: charts and graphs help you apply theory.

R4: you can find the student has learnt the topic but has not understood it so through the worksheet when working with others it can help him to understand and analyze questions.

In school Q one learner noted that textbooks can help them in remembering and understanding concepts. This indicates that use of textbooks promotes up to the second level of Bloom's taxonomy which is the understanding level. However, a well written text book with questions, graphs and charts may enhance higher order learning outcomes as indicated by a learner in school U:

FGD Q. What learning outcomes do we obtain from using text books, graphs and charts? School U

R1: I use the textbook to revise. I like using KLB because at the end of each topic there are questions for revision and it helps me understand concepts. KLB also has diagrams, charts and graphs which can help one process and apply the knowledge gained. I refer to it myself so then I can understand better

For charts and graphs, from the FGD discussions, one can allude that it helps in achieving up to application learning outcomes. For worksheets, the learners in school R said the following:

FGD Q. What learning outcomes do we obtain from using text books, graphs and charts? School R

R4: We rarely use worksheets in our lessons and I even think we do not know what that is as far as Biology is concerned.

A learner in school R on the other hand stated that worksheets can yield understanding and analysis of learning outcomes. This means that worksheets assist learners to acquire higher order learning outcomes up to the analysis level in the Bloom's taxonomy, which is more than textbooks, charts and graphs. Worksheets also allow collaboration learning which further helps in better acquisition of knowledge. These findings are in congruent with Admire & Patience (2024) who notes that text book resources promote memorization and if well illustrated can promote better learning outcomes while use of worksheets may promote higher

outcomes such as analysis. From the learners' FGD discussions, therefore, one can conclude that among material resources, use of worksheets helped learners attain higher learning outcomes while use of textbooks mostly enhanced remembering as the main learning outcome which is a low order outcome.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on use of Material Resources

In as much as the study established from the quantitative study that all teachers use text books in the teaching and learning of Biology, from the qualitative study an issue of text books having typos and grammatical errors came out. These findings differ from recommendations of researchers such as Sayan & Mertoğlu (2020) who note that textbooks being the most consulted resource necessitate the need for the content therein to be authentic, accurate and adherent to the laid-down curriculum guidelines. These findings were therefore disappointing given that most teachers and students solely rely on text books for teaching and learning. Through the interviews, the researcher further established that there was an element of wastage of time when students had to copy notes directly from textbooks. This finding implied that there could be a shortage of text books in some schools making worse the situation of low achievement of learning outcomes.

The study found out that while most teachers in the quantitative study indicated that charts, graphs and worksheets could contribute highly in the achievement of learning outcomes, from the qualitative study it was established that charts, graphs and worksheets were less used in teaching and learning of biology hence the probable reason of the low achievement of learning outcomes. These findings do not support suggestions from researchers like Mbatia, Wanjala, & Edome, (2020) who advise that

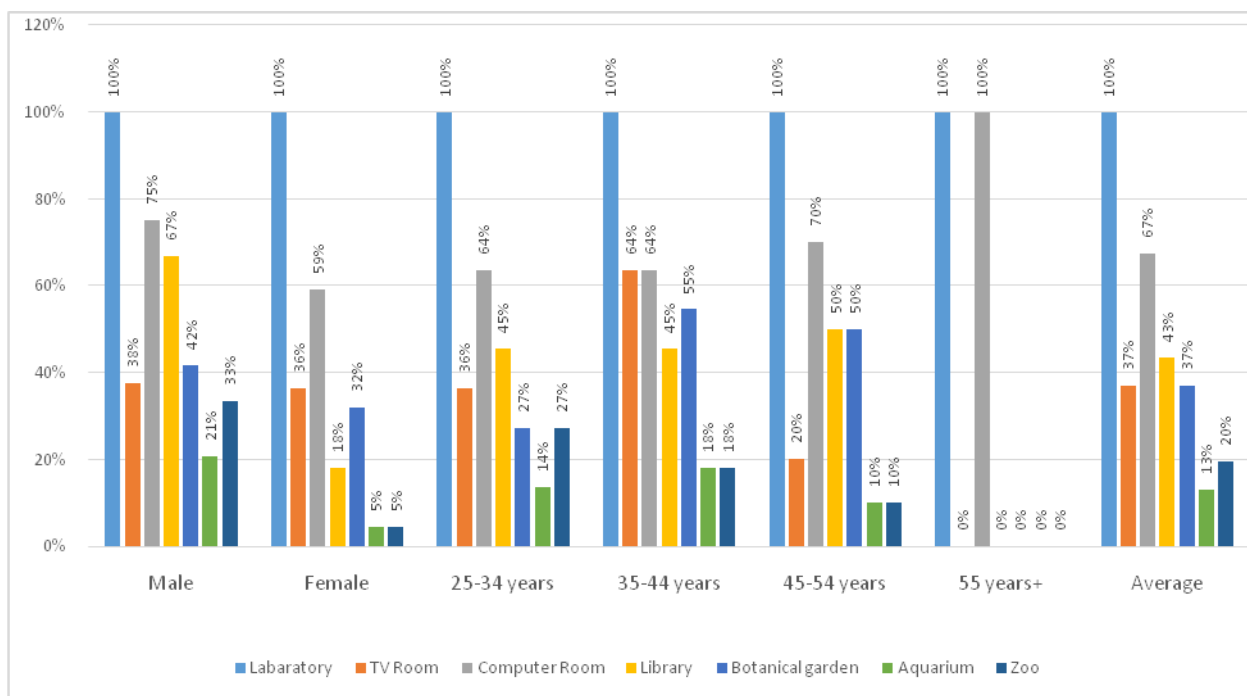
use of materials resources such as charts, graphs and worksheets which promote visualization and consequently contribute to high achievement of learning outcomes. The scenario of use of charts, graphs and worksheets is therefore wanting and need to be revitalized.

4.3.2 Use of Infrastructure Resources

Findings from the Quantitative Study on use of Infrastructure Resources

The teachers were requested to show the extent to which they used the listed infrastructure resources. Figure 4.4 shows the answers on the use of infrastructure resources in the teaching of Biology.

Figure 4.4: Use of Infrastructure Resources



All the 100 (100%) teachers across all gender, ages and teaching experience, who participated in the study, stated that they use laboratories during the teaching of Biology. This suggests that teachers appreciated the importance of using a laboratory in teaching Biology. This finding agrees with researchers (Tarusha & Gjuzi, 2024)

who indicate that laboratory use is vital in Biology teaching. This finding therefore shows that the teachers understood the importance of teaching Biology from the laboratory. Regarding the usage of computer rooms, a good number of teachers, (67%), indicated that they used computer rooms in the teaching of Biology. This shows that teachers found use of computer rooms useful. This finding agrees with (Admire & Patience, 2024)'s research findings that teaching in the computer rooms is preferred by many Biology teachers. This finding is positive in the sense that many Biology teachers are embracing or would like to teach from the computer room.

From the present study, it is unfortunate that the majority, 57 (57%) of the teachers never referred students to the library for further research. This is in contradiction with (Amoah, Emina, Ngman-Wara, & Azure, 2023) who noted that library use is important and should be embraced by all Biology teachers. Regarding utilization of the TV room, 63% of the teachers never used a television room in teaching Biology. This finding is in sync with (Ergado, Desta, & Mehta, 2022) who state that while the TV room can enhance learning, many educators see the TV room as a place of entertainment. In this study, therefore, it looks like most teachers assumed that the TV room was exclusively for entertainment. It is also probable that since many schools lacked the TV room, teachers did not think of sending the learners to the TV room for further learning.

On the use of the botanical garden, only a few teachers utilized one. Majority of them (63; 63%) did not use a botanical garden for teaching Biology. This finding concurs with Krtková (2024) who states that botanical gardens can help in the study of plants although they are not used by many teachers in teaching Biology because

they are unavailable. One may conclude therefore that Botanical gardens were unpopular most likely because many schools lacked botanical gardens and even the few schools that had them did not utilize them fully. This was the case even though many teachers appreciated that use of botanical gardens could be helpful. On utilization of zoos and aquariums in teaching Biology, only 20% of the teachers showed that they used a zoo. Majority of them (80; 80%) did not use a zoo in teaching Biology. On the other hand, 87% of the teachers never used an aquarium. Only 13 (13%) of the teachers who participated in the study indicated that they used an aquarium in teaching Biology. These findings concur with Schilbert & Scheersoi (2022) who state that use of zoos and aquariums is limited because of their unavailability besides ethical and animal welfare concerns. One can therefore conclude that the usage of the two infrastructures, the zoo and the aquarium, was less by Biology teachers most likely due to their unavailability.

After establishing how infrastructure resources were utilized in Biology teaching, the researcher sought to find out how infrastructure resources influence learning outcomes. In the quantitative study, the Biology teachers who participated in the survey were asked for their opinion on a scale of 1-5 (with 1 being the lowest rate and 5 the highest) the extent to which different infrastructure resources contributed to the achievement of learning outcomes.

Table 4.3 shows the responses on the extent to which infrastructure resources contribute to learning outcomes.

Table 4.3: Responses on the extent to which infrastructure resources contribute to learning outcomes

Teacher Characteristics		Laboratory	TV Room	Computer Room	Library	Botanical garden	Aquarium	Zoo
Gender	Male	4.54	3.25	4.29	4.08	3.75	3.38	3.33
	Female	4.27	3.14	3.50	3.32	3.41	3.05	2.86
	Total	4.41	3.20	3.91	3.72	3.59	3.22	3.11
Age	25-34 years	4.27	3.18	3.82	3.86	3.59	3.23	3.09
	35-44 years	4.36	3.82	3.91	3.73	4.00	3.55	3.45
	45-54 years	4.90	2.80	4.20	3.60	3.30	3.00	2.90
	55 years+	4.00	2.33	3.67	3.00	3.00	2.67	2.67
	Total	4.41	3.20	3.91	3.72	3.59	3.22	3.11
Experience	4 years - 5-10 years	3.75	2.38	3.50	3.38	3.38	3.00	2.63
	11-15 years	4.52	3.70	3.96	4.04	3.83	3.52	3.39
	16-20 years	4.40	3.80	4.00	4.00	4.00	3.60	3.60
	21-25 years	5.00	1.00	5.00	1.00	1.00	1.00	1.00
	30 years and above	5.00	2.50	3.75	3.50	3.25	2.25	2.50
	Total	4.40	2.60	4.20	3.20	3.20	3.00	3.00
	Average	4.41	3.20	3.91	3.72	3.59	3.22	3.11

The laboratory use was rated 4.41 as the most important infrastructure in contributing towards achievement of learning outcomes. These findings agree with (Karunakaran & Dhanawardana, 2023) who note that the laboratory environment allows students to engage in hands-on experimentation which are believed to promote achievement of learning outcomes. This finding show that the teachers understood that laboratory use in teaching Biology plays a vital role in the achievement of learning outcomes even though during the classroom observations laboratories were not being used adequately.

Regarding computer room utilization, the teachers rated computer room use at 3.91 as the second most important infrastructure among the listed infrastructure in contributing to the achievement of learning outcomes. This finding agrees with (Nayab, Fatima, & Jabeen, 2021) who state that computer room use may significantly improve students' achievement as it brings understanding of abstract biological concepts. One may therefore conclude from the findings of the present study that teachers are making an attempt to use computer rooms in teaching of Biology but yet to be well embraced probably due to lack of computer resources and knowhow.

The libraries were rated at 3.72. These findings show that some teachers appreciated library use to build on the achievement of learning outcomes in Biology teaching. This concurs with Amoah et al (2023) who state that some teachers understand that utilization of libraries significantly impact on students' academic performance. The botanical garden was given a rating of 3.59, meaning that teachers are aware that a botanical garden is vital in Biology teaching as it promotes achievement of higher levels of cognitive outcomes such as analysis and skills, such as observation (Strgar et al, 2019). These findings of the current study show that teachers appreciate that use of infrastructures such as library and botanical garden can well promote high achievement of learning outcomes even though they were not using them sufficiently.

Television rooms were rated at 3.20 on a scale of 1-5 (with 1 being a low rate and 5 being a high rate) in enhancing the achievement of learning outcomes among learners. This finding shows that the teachers agreed with (Masu & Abe, 2025) who note that learning of Biology in the Television room may enhance attainment of

learning outcomes. This shows that teachers found use of TV rooms somewhat useful in contribution to the achievement of learning outcomes. TV room use therefore should be encouraged as it has the potential to engage students which in turn can promote learning.

The aquarium and the zoo were given a rating of 3.22 and 3.11 respectively (with 1 being a low rate and 5 being a high rate.). Using zoos and aquariums in teaching Biology can promote high understanding of aquatic and biological ecosystems, enhancing students' critical thinking skills and scientific inquiry such as hypothesis testing and data analysis (Juniar, Fardilah, & Tambunan, 2021). Use of zoos and aquarium in teaching Biology may therefore contribute greatly to the achievement of learning outcomes. Overall, teachers rated high on the botanical garden, the aquarium and the zoo in teaching Biology (above 3 in a scale of 1-5). Teachers thus noted that these infrastructures were useful in contributing to achievement of learning outcomes. These findings show that teachers appreciated the use of different infrastructure in promoting the achievement of learning outcomes but unfortunately, they were not utilizing the most the desired infrastructure.

Findings from the Qualitative Study on use of Infrastructure Resources

From the Qualitative study, the researcher sought to find out from the key informants how best infrastructure may be used in the teaching and learning of Biology. For infrastructure use, Key informants had this to say.

KII Q: how best can infrastructure such as the classroom, laboratory, computer room, library, and TV room be used in the teaching and learning of Biology? KI Y

Biology is a practical subject. You cannot split Biology and laboratory because, for improvement of learning outcomes, you must do research which is field based or laboratory based.

Key informant Y emphasized that Biology, being a practical subject, should not be separated from the laboratory. Key informant Y noted that the laboratory needs to be used for research. The informant thus preferred that Biology teaching should take place in the laboratory.

Key informant X shared the same opinions about laboratory use as follows:

KII Q: how best can infrastructure such as the classroom, laboratory, computer room, library, and TV room be used in the teaching and learning of Biology? KI X

From my own experience, teachers of Biology should be stationed in the laboratories. Before teaching anything, they should have a prior experience in the laboratory to observe what happens. For example, if they want to demonstrate how catalase enzyme reacts with hydrogen peroxide, they should test.

I know that due to scarcity of space, in some schools laboratories are being used as the classrooms due to high population but that is not correct. Single lessons are the ones that can be taught in the classroom. The double lessons should be taught in the laboratory for practicals, not in the classroom. This is to allow learners to practice what they learnt in class. Students may use the computer room and the library for further research to get more information. They may also use the TV room to view happenings related to Biology.

Key informant X equally emphasized the importance of utilizing the laboratory for practical lessons in Biology teaching and learning. The informant noted that the laboratory should be used by the teachers to do experiments prior to exposing the learners to the same experiments. This shows that KI X thought it was important for the teacher to be knowledgeable for the expectations of the experiment so as to guide learners appropriately. Key informant X also stated that the laboratory should be used to do experiments to practice and ascertain what is learnt in classrooms meaning that there is need to link theory with practice. These findings agree with researchers Keengwe (2022) who indicate that after classroom lessons, laboratory use is vital in Biology teaching. Laboratory environment allows students to engage in hands-on experimentation and observation, which can deepen their understanding

of biological concepts. Unfortunately, according to the findings of this present study, the laboratory was used as a teaching room and not for the recommended use such as doing experiments and ascertaining knowledge learnt in class.

For the computer room use, Key Informant X advised that students and teachers should use the computer room for research implying that, apart from knowledge taught, there is still room for research and the computer room can provide this chance. Regarding TV room use, the informant advised that the TV room should be used for viewing reality happenings related to Biology. This means that it is important to bring Biology to the reality of the happenings in life. These recommendations by the key informants on laboratory, classroom, library, computer room and TV room use are in line with researchers NyasakaOrina et al (2022) who note that the library allows for research and should be embraced by all teachers and students. The informants' position on use of the computer room and TV room concurs with Karunakaran & Dhanawardana (2023) who indicate that the TV room allows for piquing students' interest and should be encouraged while the computer room can promote further research. From these findings therefore teaching and learning of Biology should be carried out using diversified infrastructure so as to bring a rich attainment of knowledge, skills and attitudes since different infrastructure play unique roles.

The researcher, using classroom observation guides, observed both a single lesson and a double lesson in the six selected schools, noting how the classroom and the laboratory were utilized.

In school Q, both the single and the double lessons were being taught from the laboratory on the day of visit. Even though the lessons were conducted inside the

laboratory, no experiments were done during the lessons observed. In school R, both the single and double lesson were held in the classroom. In School S, both the single and the double lessons were held in the ICT room. The ICT room in school S had no computers but had a white board and projector. In school T, the single lesson was done in the classroom while the double lesson was done in the laboratory. No experiments were however observed during the double lesson in the laboratory. In schools U and V, both the single and the double lessons were held in the classroom. In all the lessons observed, there was no reference made for the learners to use the library, computer room nor TV room. These findings show that infrastructure use in the schools observed was mostly classroom, laboratory but not for experiments and ICT room but not for research but rather for projection of notes and diagrams for students to view. None of the schools observed was using infrastructure such as library, TV room, botanical garden, zoo and aquarium on the day of visit. These findings show that learning of Biology was limited to the classroom and the laboratory and even so the laboratory was not used for experiments but a mere room for learning.

The findings on use of different infrastructure from the class observations deviate from the recommendations of researchers (Rapholo, Lelliott & Rauscher, 2018) who advise that use of laboratories should be for experiments and not as rooms for teaching; (Admire & Patience, 2024) who note that the ICT room is a good resource to be used for research; and Masu & Abe (2025) who indicate that the TV room allows for piquing students' interest and should be encouraged while the computer room can promote further research. These findings therefore show that

infrastructure in schools is either underutilized or unavailable hence insufficient use of diversified infrastructure to promote learning.

Further, the researcher sought from key informants how different infrastructure resources such as the laboratory, the classroom, the library, the computer room, the TV room, the botanical garden, the aquarium and the zoo influence the achievement of learning outcomes. The informants had this to say.

KII Q: how can the following infrastructure influence the achievement of learning outcomes: laboratory, classroom, computer room, library, TV room, botanical garden, aquarium and zoo? KIW

The laboratories, if used for practicals, provide for hands-on working promoting not only cognitive skills such as application but also developing skills such as observation, measurement and experimentation. Exclusive classroom use may promote low cognitive order outcomes such as remembering. The computer room helps students to research and apply concepts. By comparing different researched concepts they are able to analyze and come up with conclusions. The library can also promote comprehension due to research as well as analysis. The TV room can bring practical applications and a deep understanding. The botanical garden, the aquarium and the zoo can help learners attain higher order cognitive skills such as application, analysis and synthesize as well as skills outcome such as hypothesis creation. The three also enhance positive attitudes to the subject which can promote learning.

Key informant W noted that a laboratory, because it allows for practicals, can promote both cognitive outcomes such as application and also skills outcomes such as observation, measurement and experimentation. This finding shows that laboratory use promotes fairly high order outcomes and needs to be used more often by teachers and learners of Biology. The key informant stated that the exclusive use of the classroom may only promote low cognitive outcomes such as remembering. This finding may suggest why many Biology learners are missing out on higher cognitive outcomes such as evaluation and synthesis (KNEC reports 2012-2023).

For both the library and the computer room, because they provide room for research, the informant noted that they may promote cognitive outcomes such comprehension

and analysis due to comparison. This finding shows that fair order outcomes such as comprehension and analysis were less realized because, as found out earlier in this study, the library and computer room were less often utilized. The key informant W indicated that the use of the botanical garden, the aquarium and the zoo, because they give learners an opportunity to interact with real plants and animals, may promote higher cognitive outcomes such as analysis and synthesis as well as skills such as hypothesis creation. They can also enhance affective outcomes of positive attitude towards learning Biology.

The researcher then sought to establish what the learners had to say about achievement of learning outcomes due to use of different infrastructure. The learners had this to say:

FGD Question: What kind of learning outcomes do you think learning from the laboratory, classroom, library, computer room, TV room, botanical garden, aquarium, and zoo brings?

School Q

R1: The laboratory has a practical study area that helps in remembrance because anything that is taught and done by your hands is easier to remember

R2: Laboratory brings about understanding to the concept that you are covering.

R3: Laboratory also improves skills like observing and helps you to remember during exams.

R4: In the laboratory, the attitude is positive. In the classroom, it is different since people in the classroom can sleep and play but, in the lab, when you have the apparatus in front of you, you can't do anything playful there. Many of the students will be active.

R1: I think the learning outcomes we get from the classroom is different for me because in the classroom a teacher might come and teach something but when they come the next day the learner might have forgotten what had been taught.

R5: We have never visited the botanical garden and the aquarium in our school. I am sure it can help us in our exams.

R2: The challenge is that we use the laboratory like a classroom instead of doing experiments. In such a case learning outcomes will be same as those in the classroom.

R1: You see in the classroom the teacher mainly just dictates notes. So you forget what you learn.

R3: I guess the computer room and library may boost our learning outcomes but are not available for use in our school. Only computer students use the computer room.

R4: Madam I have never seen an aquarium or zoo.

R5: I think the botanical garden is the one Agriculture students' use for their KCSE project.

Learners in school Q attributed the use of the laboratory to achievement of learning outcomes such as understanding, remembrance, and application. The learners also stated that the laboratory enhanced their observation and experimentation skills and as well enhanced a positive attitude towards Biology. However, even in the laboratory, the learners in most cases did not conduct experiments and in this case same learning outcomes as those attained in the classroom may be achieved. The learners disregarded learning from the classroom and stated that it was difficult to attain even simple learning outcomes like remembering. The learners in school Q further said that the classroom may encourage them to play and sleep during the lesson. This shows that the learners did not like learning from the classroom all the time.

It is notable that the learners in school Q had nothing to say about how the use of the library, computer room, TV room, aquarium and zoo on their influence on achievement of learning outcomes. They however thought that using the computer room and library may boost learning outcomes but they could not tell which ones since there were not available for them to use. This shows that learners were eager to use different infrastructure but they were not available.

These findings agree with Bwalya (2023) who state that teachers mainly teach from the regular classroom and even where laboratories are available, they are often used

as mere teaching rooms with minimal experimentation. Other infrastructure such as botanical garden and aquarium are rarely available for use in schools hence leading to under achievement of learning outcomes. This finding therefore calls for use of various infrastructure to enhance effective learning.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on Use of Infrastructure

The quantitative study pointed to massive use of laboratories in teaching Biology. This was in tandem with Amoah et al (2023)'s study on how the use of laboratories was pivotal in the implementation of contextual learning to enhance critical thinking among students. However, the qualitative study of the same alluded that most Biology learning occurred in classrooms and even the Biology lessons were carried out in the laboratories, minimal experiments were carried out. The laboratories were serving the same purpose as the customary classroom, therefore pointing to the possibility of infrastructure shortage in schools.

4.4 Application of the Biology Curriculum in Everyday Life Context

The second objective was to evaluate the application of Biology in everyday life and its influence on the achievement of learning outcomes. Application of Biology into everyday life context was viewed through two lenses: The Science Process Skills and the Nature of Science.

4.4.1 Use of Science Process Skills (SPS)

Findings from the Quantitative Study on Use of Science Process Skills

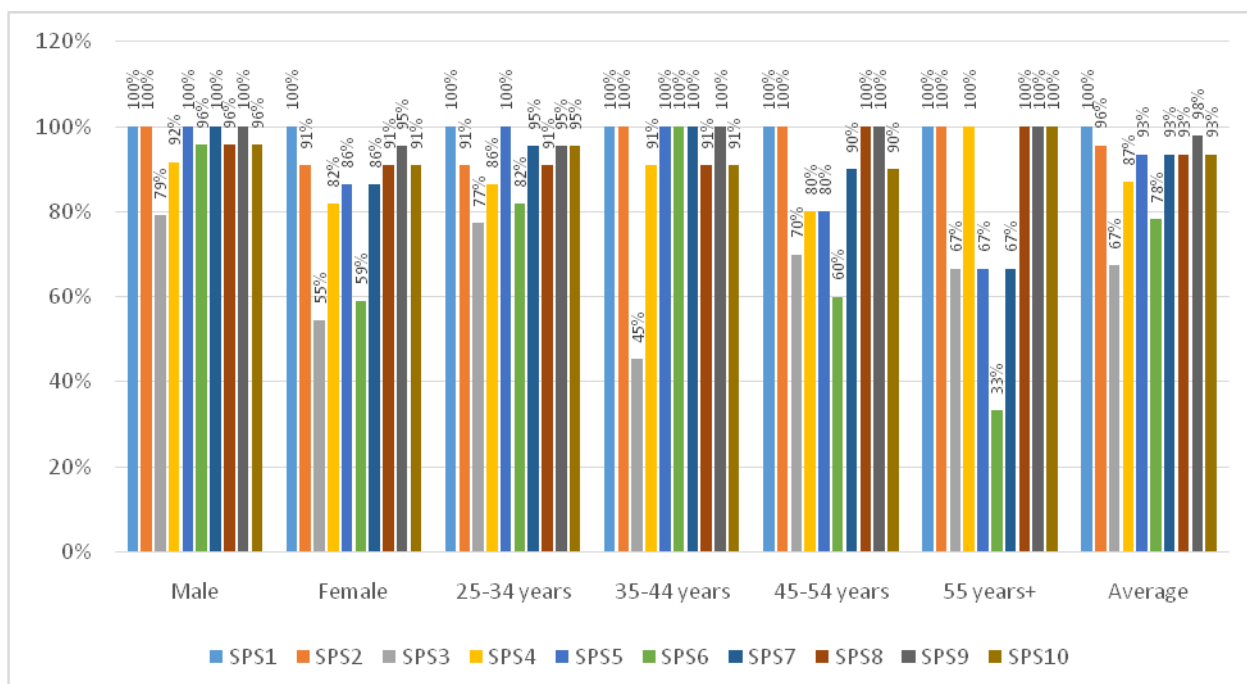
In the quantitative study, in establishing the application of Biology into everyday life through use of the Science Process Skills, the teachers who participated in the survey

were presented with 10 statements depicting the Science Process Skills (SPS) and asked to indicate if they practiced the skills in their teaching.

SPS	Description
SPS1	Use senses to identify changes and characteristics of Biological knowledge
SPS2	Use measuring instruments to obtain more appropriate value.
SPS3	Construct models for learning.
SPS4	Propose explanations as a starting point for further investigation.
SPS5	Set up experiments procedurally and repeatedly to obtain results
SPS6	Control and manipulate variables during experiments
SPS7	predict the outcome of experimental results
SPS8	Relate the observed characteristics and interpret the data
SPS9	Make conclusions from the interpreted data
SPS10	Report findings from their investigations

Figure 4.5 gives the responses of teachers on whether they practiced the listed SPS in their teaching of Biology.

Figure 4.5: Use of Science Process Skills



All the 100 teachers who participated in the study (100%) indicated that they helped students use senses to identify changes and characteristics of Biological knowledge.

In terms of the use of measuring instruments to obtain more appropriate value 96 of the 100 participants (96%) indicated that they utilized it. Encouraging students to predict outcome of results had a score of 93 respondents, similar to relating observed characteristics and interpreting data to make conclusions. Nearly all teachers (98%) stated that their students are made to report findings from their investigations. However, it is noted that the figure reduced to (67) 67% when they were asked if they helped students to construct models for learning while only 33 teachers (33%) indicated that they helped students control and manipulate variables during experiments.

These results mean that over 90% of the teachers used observation, measurement, experimental and prediction process skills in teaching Biology. Construction of models for learning and controlling variables science process skills were less popular. This means that learners had little exposure to higher process skills. These findings agree with researchers' Gatica (2024) findings who states that in as much as there is an attempt by teachers to utilize science process skills in their teaching, only basic SPS such as observation, measurement and experiment skills have been achieved. In this study, therefore, it was imperative to note that higher SPS such as manipulating variables and construction of models were yet to be realized. It was also likely that these Science Process Skills that the teachers indicated they used were done on rare occasions. This is because from the earlier findings of this study, experiments and projects that would have allowed for a range of the SPS were not common in Biology teaching.

Further analysis was carried out to find out if there were any significant correlations between the characteristics of the teacher namely gender, age and experience and

SPS use. Table 4.4 shows the correlation between the teacher characteristics and SPS use.

Table 4.4: Correlation between the Teacher Characteristics and SPS use

		Correlations												
		Gender	Age	Experience	SP S1	SPS 2	SPS 3	SPS 4	SPS 5	SPS 6	SPS 7	SPS 8	SPS 9	SPS 10
Gender	Pearson Correlation	1	.174	.088	. ^a	-	-	-	-	-.445 ^{**}	-	-	-	-
	Sig. (2-tailed)		.248	.559		.137	.078	.333	.063	.002	.063	.510	.301	.510
Age	Pearson Correlation	.174	1	.834 [*]	. ^a	.191	-.094	.014	-.399 ^{**}	-	-	.146	.134	-
	Sig. (2-tailed)	.248		.000		.203	.536	.924	.006	.052	.147	.333	.376	.815
Experience	Pearson Correlation	.088	.834 ^{**}	1	. ^a	.160	-.026	-.122	-.506 ^{**}	-.313 [*]	-.224	.114	.064	-
	Sig. (2-tailed)	.559	.000			.287	.861	.418	.000	.034	.134	.451	.671	.716

** . Correlation is significant at the 0.01 level (2-tailed).
 * . Correlation is significant at the 0.05 level (2-tailed).
 a. Cannot be computed because at least one of the variables is constant.

There was a negative correlation between Gender and the Science Process Skill 6 (control and manipulate variables during experiments). Male teachers tend to use this skill more than female teachers when teaching Biology. This finding agrees with (Vincent-Lancrin, Vidal, & Yu, 2023) who suggest that there is a difference in utilization of science process skills between males and females. In this study, apart from letting the learners do a prescribed Biology experiment, male teachers indicated that they allowed learners to control and monitor reactions compared to female teachers. Thus, being the case, it can be assumed that male teachers may perform

well in instilling some process skills such as manipulation of variables than female teachers.

The findings also showed that younger teachers and teachers with less years of experience also tended to use SPS5 (setting up experiments repeatedly to obtain results). This is in agreement with other studies which reveal that younger teachers are more active to teach these skills in their classrooms than older teachers (Reagh, Yassa & Stark, 2018). This means that they could be enthusiastic in exposing learners to science process skills compared to older teachers, most likely because they were recently trained on the skills.

After establishment of how Science Process Skills were utilized, the researcher sought to find out how use of SPS influenced achievement of learning outcomes. In the quantitative study, the teachers who participated in the survey were asked to rate in a scale of 1-5 (1 being lowest and 5 highest) the extent to which the listed Science Process Skills contributed to achievement of learning outcomes. Table 4.5 shows the responses on the extent to which science process skills contribute to the achievement of learning outcomes.

Table 4.5: Extent to which Science Process Skills Contribute to Achievement of Learning Outcomes

Rating		SPS1	SPS2	SPS3	SPS4	SPS5	SPS6	SPS7	SPS8	SPS9	SPS10
Gender	Male	3.92	3.92	3.71	4.04	4.08	3.96	4.00	4.00	4.00	4.04
	Female	4.27	4.00	3.91	3.77	3.82	3.36	3.95	3.95	3.95	4.14
Age	25-34 years	4.18	4.14	3.82	4.18	4.23	3.73	4.05	4.05	3.91	4.05
	35-44 years	3.91	3.91	4.09	3.55	3.73	3.91	3.82	3.64	3.91	4.00
	45-54 years	4.00	3.70	3.50	3.70	3.60	3.20	3.90	4.10	4.10	4.20
Experience	55 years+	4.33	3.67	3.67	4.00	4.00	4.00	4.33	4.33	4.33	4.33
	4 years or less	3.75	3.63	3.63	3.75	3.75	3.50	3.75	3.75	3.63	3.88
	5-10 years	4.35	4.30	4.17	4.17	4.26	3.83	4.17	4.04	4.04	4.17
	11-15 years	3.60	3.60	3.40	3.60	3.80	3.60	3.60	3.60	3.80	3.80
	16-20 years	3.00	2.00	1.00	3.00	1.00	1.00	3.00	4.00	5.00	5.00
	21-25 years	3.75	3.50	3.25	3.50	3.75	3.75	3.75	4.25	4.00	4.00
	30 years and above	4.40	4.00	3.80	3.80	3.80	3.80	4.20	4.20	4.20	4.20
Average		4.09	3.96	3.80	3.91	3.96	3.67	3.98	3.98	3.98	4.09

Teachers rated highly the usefulness of SPSs in contributing to the achievement of learning outcomes (3.67-4.09). These findings agree with researchers Karunakaran & Dhanawardana (2023) who document the usefulness of SPS in the achievement of learning outcomes as helping learners attain improved scores, improved understanding, comprehension and analysis. This means that the teachers are aware that SPS are important and should be incorporated in Biology teaching for effective learning.

Out of the ten Science Process Skills which were listed, using senses to identify changes and characteristics of biological knowledge (observation skills) and reporting findings from investigations were rated as considerably useful, 4.09 out of 5. Controlling and manipulating variables was rated as moderately to considerably useful in influencing learning outcomes (3.67 out of 5). These findings agree with researchers Mandasari, Iwan, & Damopolii (2021) who note that even though integrated (higher) process skills would fetch higher-order learning outcomes, they are less practiced compared to the basic science process skills. These findings show that teachers appreciated basic science process skills more than the higher science skills, probably because exposing learners to the basic skills was easy to implement compared to the higher science process skills. It was however seen from the earlier findings of this study that even the basic SPS that teachers claimed to expose the learners was done less often. This means that a lot is yet to be put in place to realize use of SPS in teaching Biology.

Findings from the Qualitative Study on Use of Science Process Skills

In the qualitative study, in establishing the application of Biology into everyday life through use of the Science Process Skills, the researcher sought to find out from the key informants how teachers in the classrooms should apply Biology into everyday-life context by use of science process skills. The following are the responses:

KII Q: What is your advice on the use of science process skills in application of Biology in everyday life?KIX

If there is any problem which is biologically related it has to be identified and the student should be able to formulate or imagine some kind of answer to that problem and make a hypothesis about it. Then he should go to find out what the formulation is; is it correct or not. It is like carrying out an experiment and the data that will be collected from that can be analyzed and a conclusion reached to prove the hypothesis correct or wrong. And that is the only format and in fact not only Biology even arts that is the way of

getting a solution. That should be encouraged, even to a small child who does not know science that is the way they should be trained.

Key informant X emphasized that Biology being a science subject should be applied in life through the scientific process which includes identification of a problem, formulation of a hypothesis, experimentation in order to find out if the hypothesis is correct or wrong, collection and analysis of data from the experiment, making conclusions to prove the hypothesis as right or wrong. The key informant embraced the scientific process as a way of life which should be practiced even in art disciplines and should be taught to young children. This finding agrees with researchers Gizaw & Sorsa (2023) who emphasize that Science Process Skills (SPS) are not only used during science education but that SPS are part and parcel of life. This finding thus suggests that individuals who do not use science process skills in their everyday life will have difficulty succeeding in life. Utilization of Science Process Skills (SPS) in the teaching of Biology therefore enables students to gain the skills necessary to solve everyday problems.

On the same concern on how teachers in the classrooms may apply Biology into everyday life by use of science process skills, Key informant Y said the following:

What is your advice on the use of science process skills in application of Biology in everyday life?KIY

There are a number of science process skills that learners have been given room to know in the curriculum design: observation skills, practical skills and higher skills. There are a number of these skills which will get them to link the learning area with real life situation. For example a learner will know that ‘ I have observed that as I was conducting this experiment, manipulation skills I was able to manipulate these tools and get this observation so this so when you get to this you will be able to make a conclusion which is also a science process skill.’ The SPS are in order basic and higher and in the new CBC curriculum guidelines the learner will have room to conduct research, to carry experiments including the higher process skills. The problem that happens like in the case of 8-4-4 is that the teacher dwells on assessment rather than the curriculum guidelines...

The key informant Y identified that in the curriculum guidelines, learners have been given room to experience a number of science process skills such as observation skills, practical skills and other higher order science process skills. The key informant indicated that the science process skills help link Biology to real life situation for instance a learner may observe a phenomenon, conduct experiments, manipulate variables and make conclusions. The key informant was optimistic that with the new CBC curriculum guidelines, even higher order science process skills may be obtained unlike with the 8-4-4 case. This finding agrees with Gizaw & Sorsa (2023) who note that Biology is not only about content, but the method of acquisition through the Science Process Skills (SPS) which often brings the context that impacts learning. In this study however, this finding was negated in that with the 8-4-4 system of education, despite the curriculum guidelines the teachers ignored the suggested Science Process Skills (SPS) and dwelled on the assessment part. The irony however is, learners performed poorly in their Biology examinations as seen in KNEC reports 2013-2023.

The Key informant W, just like key informant Y, was optimistic that with the incoming CBC, there is a chance of the SPS to be well implemented and hence good application of Biology to everyday life. In as much as the Competency Based Curriculum promises to correct this anomaly of overemphasizing on assessment at the expense of the SPS, one is left to worry about what becomes of the present 8-4-4 learner consumers and if indeed CBC will live its promise and not turn out like the 8-4-4 curriculum, which was also full of good promises at its inception.

The researcher proceeded to find out from the learners through the FGDs how their teachers used science process skills to apply Biology to everyday life. In all the schools visited except one the learners did not point out to any instances where their teachers used science process skills to apply Biology to

everyday life. The following are some of the responses from learners concerning application of Biology to everyday life through the use of science process skills. **FGD Q: How does your teacher point out Biology applications in life during the lesson? School R**

R3: like the sub topic of pollination we can get several flowers and the teacher shows us how pollination is taking place in a plant and we observe.

R1: the topic cell division the teacher will come to class with his laptop to show us a video of the cell division and tell us to observe and report how the cell division takes place in the human body.

R2: when estimating the population like line transect, belt transect, we used apparatus such as tape measure and meter rule.

The learners pointed out that in the topic of pollination, the teacher helped them observe the pollination process occurring in the flowers they collected. In cell division, the learners watched a video and reported how cell division took place in the human body. In population estimation, the learners indicated that they used different apparatus such as meter ruler and tape measure. The main science process skills that were coming out in school R were observation, measurement and communication which were through reporting of findings. Even though in the earlier findings of this study teachers indicated that they used various SPS such as manipulation of variables during teaching of Biology, it is evident that from the learners FGDs, teachers rarely used SPS and when they did use it was unintentional. Further, only basic SPS such as observation and measurement were common.

The researcher, to follow up on school R learners' FGD, observed a lesson in the school as follows:

***Class observation: Use of SPS in Application of Biology to Everyday Life
School R***

T: Observe the causative agents of diseases displayed. what is the causative agent of cholera

L1: Vibrio cholerae

T: How is it different from the one that causes typhoid?

L2: The one that causes typhoid is called Salmonella typhi.

L3: vibrio cholera is coma shaped while salmonella typhi live in colonies and are kind of circular

The teacher displayed diagrams of different causative agents of diseases. He asked the learners to observe the diagrams and differentiate between the causative agents of the bacteria that cause cholera and the bacteria that cause typhoid. From the class observations, only the science process skill of ‘observation’ was observed in school R. This finding of the researcher’s observation is congruent with the learners’ FGDs where use of SPS was found to be scarce and complete ignorance of higher order SPS. This finding is pessimistic given that from the earlier findings of this study, SPS is a vehicle through which learners can understand Biology concepts and relate them to the way of life. It means that without acquisition of the Science Process Skills and especially the higher order process skills, learners may not be able to come up with solutions to solve societal problems which is one of the main goal of science education as portrayed in the Kenya Vision 2030.

The findings from the learners’ FGD and the class observation depict a scenario of learners’ poor exposure to science process skills and most probable underachievement of Biology learning outcomes. According to a study by Juniar, Fardilah, & Tambunan (2021), students who got instruction that was centered on developing science process skills in Biology outperformed those who received conventional instruction. It is unfortunate therefore that a Science like Biology is taught in isolation of the science process involved in knowing Biology. It is the likely reason why most learners find Biology concepts abstract and difficult to comprehend and apply in life. The Science Process Skills (SPS) of knowing should therefore be part and parcel of teaching and learning Biology.

The researcher, through the qualitative study, further sought from the key informants how Science Process Skills contributed to achievement of learning outcomes. The following were the responses:

KI Q: How do you think application of Biology in everyday life through SPS can influence learning outcomes? KI X

If students are trained to think and work like scientists, it is going to improve. You see, removing them from just reading, you see, students do more of reading of text books than maybe discussing with the teacher. You see when students engaging themselves in the science they understand more. An investigation to do they discover more when they just reading. They come to understand more of the things they could not see by just reading the notes. There is a big relationship that process of science, if done well, can enhance in achievement of learning outcomes including higher order thinking skills because they form hypothesis and will ask themselves 'if I did this what will happen'? In addition, the intended skills such as observation, measurement, experimentation and inference-making will be attained. Science process skills also make the learners have a high interest to learn Biology and of course this will lead to high achievement of learning.

Key informant X indicated that use of SPS will show an improvement in attainment of learning outcomes. He stated that by keeping learners away from reading textbooks, it encourages discussion with the teacher. By engaging learners, they understand better the things they will not have understood by reading notes. The key informant X further indicated that if the use of science process skills is well done, it can enhance achievement of high order cognitive outcomes such as synthesis. Also, such as learners making a hypothesis and making their own knowledge from experimental findings. Science process skills also enhance intended skill outcomes such as observation, measurement, manipulation of variable, and making inferences. Consequently, science process skills create a great interest in learning Biology hence high achievement of learning outcomes.

From key informant X, science process skills lead to a whole round achievement of all learning outcomes namely cognitive, skills and affective. These findings agree

with Xue & Li (2021) who state that Science Process Skills stimulate cognitive, skills and affective processing. Application of Biology to everyday life through use of Science Process Skills is therefore likely to lead to attainment of whole intended outcomes including the understanding of life and not only for academic achievement. Science Process Skills may therefore enhance lifelong learning which the essence of schooling is about.

The researcher sought to find out from the learners whose teacher was observed in school R using science process skills, how science process skills influenced achievement of learning outcomes. The following are the responses from the learners' FGDs:

FGD Q *How useful do you find it when your teachers apply Biology to everyday life through science process skills?* School R

R1: *Makes Biology very interesting to study*

R4: *It can be very good in application and analysis questions in the exams*

R6: *But some people think if you concentrate on things outside the textbook you may not pass exams. For me, I like it when we do applications to life. It can help you answer things you have not been taught directly.*

From the responses above, it is evident that some students subscribe to the notion that they can pass exams only if biology is applied to everyday life they can achieve high level outcomes such as application and analysis. They found this knowledge handy in even things which are not directly explained in the text books. In addition, it helps in making Biology interesting. These findings concur with Xue & Li, (2021) who indicate that Science Process Skills (SPS) brings the context and helps in understanding of concepts even when it is not explicitly addressed. These findings mean that students appreciate the use of SPS in learning as it enhances better understanding and application of Biology. Biology being a science of life, science process skills may not be sidelined during the process of teaching and learning it.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on use of SPS

While the quantitative study portrayed a wide and almost instinctive use of SPS, it was clear that in the qualitative study only the basic SPS were utilised. According to Gatica (2024), construction of models around readily available SPS which are higher level SPS are pivotal in improving learning outcomes. Leaning more towards basic exposure to SPS may negatively impact students' achievement of learning outcomes because students may fail to grasp core concepts that can be expounded through use of SPS. The qualitative study however brings out optimism that the incoming CBC syllabus provides an opportunity to fully utilize SPS. This is important as the curriculum guidelines provide room for guidance on the utilization of SPS (Gizaw & Sorsa, 2023). SPS is thus to be intentionally utilized since the method of acquisition of biological content is just as important as the content itself.

4.4.2 Use of the Nature of Science (NoS)

Quantitative Study on Nature of Science (NoS)

In the quantitative study in establishing the application of Biology into everyday life through use of the Nature of Science (NoS), the teachers who participated in the survey were presented with 8 statements depicting the Nature of Science (NoS) and asked if they portrayed the statements in their teaching.

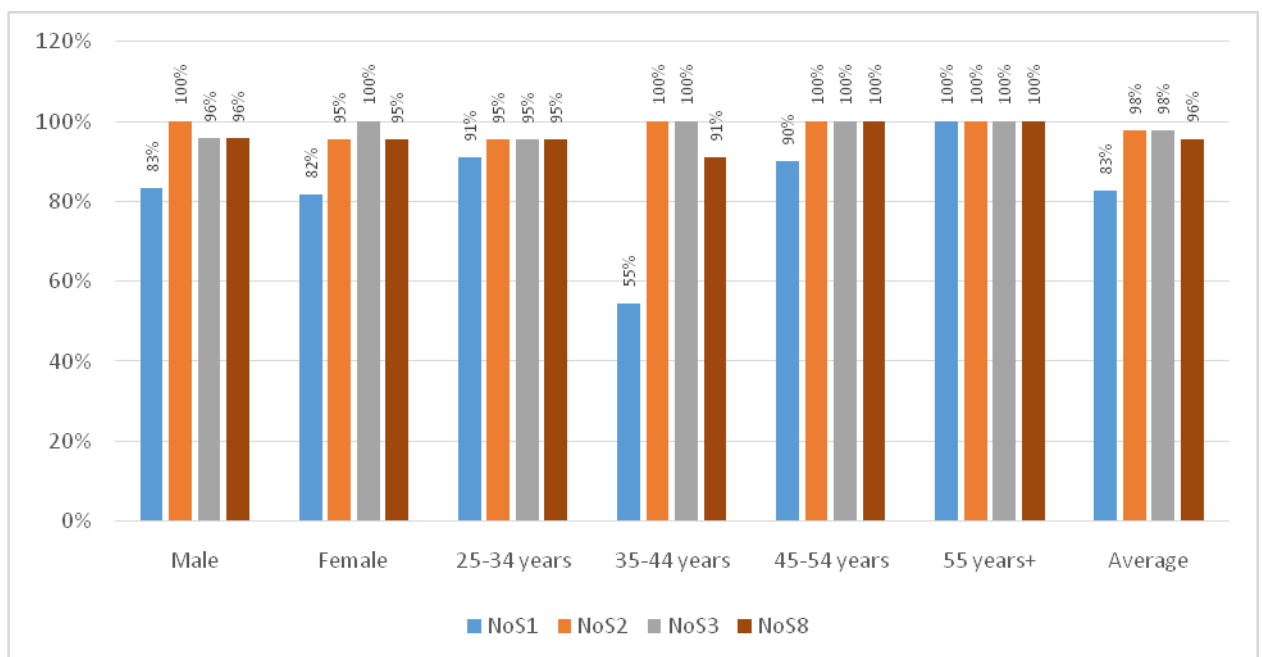
- NoS1 Portray Biology Knowledge as tentative and not final/robust
- NoS2 Give room for students to use more than one method of investigation
- NoS3 Give room for creativity and imagination
- NoS4 Guide on clear distinction between observations and

inferences

- NoS5 Guide on clear distinction between theory and law
- NoS6 Identify and acknowledges names of scientists associated with the Biological discovery/knowledge
- NoS7 Give room for socio- cultural knowledge to influence Biology knowledge
- NoS8 Give opportunities for learners to associate Biology knowledge with social realities in the society

Figure 4.6 shows the teachers' respondents on whether they portrayed the nature of science in the teaching of Biology.

Figure 4.6: Use of the Nature of Science



From the teachers' responses, most teachers, (83-98 out of 100; 83%-98%) teachers appreciated the usefulness of the application of Biology to everyday life using the various aspects of the Nature of Science (NoS). Majority of the respondents, 98 teachers out of 100 (98%) indicated that they give room for students to use more than one method of investigation, while the same proportion of 98% indicated that they emphasize on method of investigation in learning Biology. These findings agree

with researcher Donley (2024) who states that teachers appreciate the use of the nature of science as it gives learners a better experience of Biology. These findings show that teachers understand that the use of various aspects of the nature of science is important in giving learners a rich experience in Biology. This could be an optimistic finding if indeed the teachers were to put into practice their thoughts of the nature of science in the teaching of Biology.

Further analysis was carried out to find out if there were any significant correlations between the characteristics of the teacher, namely gender, age and experience and the use of the Nature of Science (NoS). Table 4.6 shows the correlation between the teacher characteristics and NoS use.

Table 4.6: Correlation between the teacher characteristics and NoS use

		Correlations										
		Gen der	Age	Expe rienc e	NoS 1	NoS 2	NoS 3	NoS4	NoS5	NoS 6	NoS 7	NoS 8
Gender	Pearson Correlati on	1	.174	.088	-.020	-.156	.143	-.276	-.405**	-.275	.042	-.009
	Sig. (2- tailed)		.248	.559	.895	.301	.344	.063	.005	.064	.781	.951
Age	Pearson Correlati on	.174	1	.834* *	-.003	.134	.134	.055	-.119	-.119	.068	.081
	Sig. (2- tailed)	.248		.000	.986	.376	.376	.715	.432	.432	.654	.591
Exper ience	Pearson Correlati on	.088	.834 **	1	.051	.064	.064	.058	-.081	-.122	.011	.024
	Sig. (2- tailed)	.559	.000		.736	.671	.671	.704	.593	.418	.942	.876

** . Correlation is significant at the 0.01 level (2-tailed).
* . Correlation is significant at the 0.05 level (2-tailed).

The findings showed that male teachers tended to use NoS5 (guide on clear distinction between theory and law) more than the female teachers. This finding is contrary to reports by researchers that indicate no significant relationship between science teachers' gender and their conceptions of the NoS (Donley, 2024). However, sufficient research hasn't been carried out to warrant a conclusion regarding the influence of gender on teachers' NoS use. This finding therefore suggests that an emphasis should be made on the use of the nature of science aspect of guiding the learners on clear distinction between theories and laws of Biology by all genders so as to give learners a better experience of Biology.

After determining how teachers used the nature of science in the application of Biology to everyday life, the researcher sought to find out how the nature of science influences the achievement of learning outcomes. In the quantitative study, the teachers who participated in the survey were asked to rate in a scale of 1-5 (1 lowest 5 highest) the extent to which the NoS statements contributed to achievement of learning outcomes.

Table 4.7 shows the responses on the extent to which Nature of science (NoS) contributes to Learning Outcomes.

Table 4.7: The extent to which Nature of science (NoS) contributes to Learning Outcomes

Rating		NoS1	NoS2	NoS3	NoS4	NoS5	NoS6	NoS7	NoS8
Gender	Male	3.67	4.13	4.13	4.04	4.00	3.92	3.75	3.92
	Female	3.86	3.86	4.00	3.95	3.50	3.45	3.82	4.05
Age	25-34 years	3.73	4.00	4.05	4.00	3.86	3.77	3.64	4.00
	35-44 years	3.36	3.91	4.09	3.91	3.45	3.36	3.64	3.82
	45-54 years	4.20	4.00	4.00	4.10	4.00	4.00	4.20	4.00
	55 years+	4.00	4.33	4.33	4.00	3.33	3.33	4.00	4.33
Experience	4 years or less	3.75	3.63	3.88	3.63	3.63	3.63	3.63	4.00
	5-10 years	4.04	4.26	4.26	4.26	3.91	3.83	3.83	4.09
	11-15 years	2.20	3.40	3.60	3.40	3.40	3.20	3.20	3.20
	16-20 years	5.00	4.00	5.00	5.00	4.00	5.00	5.00	5.00
	21-25 years	3.25	3.50	3.25	3.50	3.50	3.25	4.00	3.75
	30 years and above	4.20	4.40	4.40	4.20	3.80	3.80	4.00	4.20
	Average	3.76	4.00	4.07	4.00	3.76	3.70	3.78	3.98

Majority of teachers rated highly (3.70-4.07 out of 5) the usefulness of appreciating the nature of science in the teaching of Biology in contributing to the achievement of learning outcomes. Giving room for creativity and imagination aspect of the nature of science was rated as the most useful, being considerably useful with a rating of 4.07 out of 5 while Portraying Biology as tentative and not robust was rated the lowest at 3.7 out 5, quite lower than other ratings by the respondents.

This finding implies that most likely Biology is taught in a static manner which does not allow room for changes. This concurs with Clough & Olson (2021) who state

that Biology is portrayed as unchanging and this may result in misconceptions and less accurate understandings of Biology. These findings therefore suggest a limitation to the growth of Biology knowledge and consequently inadequate achievement of learning outcomes. Teachers seemed to understand the role of creativity and imagination in teaching Biology as they rated it high (4.07 out 5). This concurs with (Superfine, Ko, & Goldman, 2022) that employing imagination and creativity in Biology lessons improved students' understanding of scientific topics. This finding is encouraging if indeed teachers provide opportunities for learners to synthesis instances of Biology in relation to everyday life. This is thus likely to improve students' comprehensiveness and application of Biology.

Qualitative Study on Nature of Science (NoS)

In the qualitative study in establishing the application of Biology into everyday life through use of the Nature of Science (NoS), the researcher sought to find out from the key informants how teachers in the classrooms should apply Biology into everyday life context by use of the Nature of Science (NoS). Out of the 8 aspects of the nature of science that the researcher had outlined, the key informants talked of 4 aspects of the nature of science namely: Portray Biology Knowledge as tentative and not final/robust; Give opportunities for learners to associate Biology knowledge with social realities; Give room for creativity and imagination; Guide on clear distinction between theory and law and how they may be used in application of Biology to everyday life. The following are the responses:

KII Q: How should teachers use the nature of science in applying Biology knowledge to everyday life?KIX

People who have gone to the university level should know that knowledge is not final. Today what you knew as the correct thing, you will find in the evening that it has changed. During my time those years, we had only two classes of naming organisms, you are either a plant or animal. If non-living

we don't call it Biology. Although the relationship between nonliving and living is called ecology, you find that there is a relationship. By the time I was coming out of the system, we had how many kingdoms? 5. Monera , protoctista, fungi, animalia and plantae. From the two I knew those years. The biggest problem is how do we portray the knowledge we are teaching? Many teachers teach it as final knowledge. Teachers ought to present knowledge as tentative and not final.

The key informant X reported that scholars should know that knowledge is not final and can change. The key informant X gave an example of how living things were classified before into only two kingdoms plantae and animalia. This changed into five kingdom classification, namely: monera, protoctista, fungi, animalia and plantae by the time the key informant X was coming out of the school system. The key informant therefore mainly advised on the aspect of the nature of science which states that “portray knowledge as tentative and not robust”. The informant admitted that most teachers have a problem of portraying Biology knowledge as final and often teach Biology as a body of facts. This finding agrees with (Donley, 2024)’s study who noted that Biology is often taught as some facts and truths devoid of change. This portrayal of Biology as unchanging may be detrimental to the learners as they may not have room to think outside the box and add to the knowledge of Biology. Learners may also have a closed view of Biology and fail to relate it wholly to everyday life. Failure to relate Biology to everyday happenings may make students find Biology difficult to comprehend and hence affect achievement of learning outcomes.

On the same concern of how teachers in the classrooms may apply Biology into everyday life context by use of the Nature of Science (NoS), the key informant Y had this to say:

KII Q: How should teachers use the nature of science in applying Biology knowledge to everyday life?KIY

In the new CBC for the designs we have prepared, the learning area is related to every day's life. It is learning that you see not those theories that we were being taught like Vasco Da Gama. For example, if you teach a disease control you do not do it theoretically. We have what happened even in the recent past COVID 19. We have given room for creativity and innovation like imagination, critical thinking those are the competencies we would want them to develop from these designs so there is room for that. Through the society, the designs provide for community service learning where learners are sent to the community to do a study or research. In the 8-4-4 curriculum, NoS could have been a bit lacking but from the initial set ups there could have been such rooms. The teachers probably concentrated on assessment. For the 8-4-4 we dwelt on summative assessment especially so if there was an area to go to the community and do some activity it will be overlooked. We now have both formative and summative and hence the nature of science may now be applied.

The key informant Y indicated that in the new CBC guidelines, there is a clear relationship of knowledge and everyday life. The key informant Y mentioned of three main aspects of the Nature of Science (NoS) in the new curriculum guidelines and how they may be applied. The key informant indicated that teachers should emphasize on teaching what is happening and separating it from theories like Vasco da Gama. This statement alluded to the use of the aspect of NoS about “Guide on clear distinction between theory and law”. The key informant thus advised on the importance of separating laws and theories and relating Biology to present day happenings. If a teacher for instance teaches about a disease control method, the teacher should link it to a real disease like COVID19 which was a reality and not to teach that theoretically.

The second aspect of the NoS that the key informant Y mentioned is “Give room for creativity and imagination”. On this aspect, the key informant Y indicated that the new curriculum has allowed for imagination and creativity by outlining critical thinking as one of the competencies learners ought to attain. The third aspect of NoS that the key informant talked about is “Give opportunities for learners to associate Biology knowledge with realities in the society”. On this one, the key informant Y

said that the curriculum guidelines have provided for community service learning where learners are sent to the community to do a study or research.

The key informant Y admitted that in the 8-4-4 curriculum, the Nature of Science (NoS) aspects were a bit lacking but from the initial set ups of 8-4-4, there could have been room for NoS but with time the teachers probably concentrated on assessment rather than the curriculum implementation. The 8-4-4 dwelt on summative assessment. For example, if there was an area to go to the community and do some activity, it would be overlooked and rather the time used to concentrate on learning to examinable content. These findings agree with researchers who note that the challenge with application of Biology content knowledge into everyday life context through the nature of science has been the perception that it may conflict with assessments or other systemic demands (L'Heureux, 2021). The findings of the present study therefore recommend that care should be taken to emphasize on that application of Biology knowledge through the nature of science in the CBC curriculum guidelines lest it ends like the 8-4-4 which, despite the curriculum guidelines implying the use of NoS, was completely ignored. Besides, one of the key informants agreed that even in the new CBC curriculum guidelines, the Nature of Science (NoS) aspects are not clear and intentional. This is what the key informant W had to say about the attempt CBC curriculum guidelines are making in including NoS in the curriculum:

KIIIQ: I: To what extent have the CBC guidelines included aspects of the nature of science? KI W

I have gone through a number of designs up to grade 8 but may be it is not really standing out as nature of science it may imply the nature of science but it is not categorical that we are to have something around nature of science. But what I have interacted with I have not come across that.

Key informant W indicates that much as there has been an attempt to have some aspects of NoS in the so far designed curriculum guidelines, the intentionality is lacking. The key informant advises that the inclusion of the nature of science should clearly be addressed and be included in the curriculum guidelines. These findings therefore show that there is a need for precautions to be put in place to ensure successful utilization of the NoS aspects so as to make Biology relevant of its role in everyday life.

The researcher then sought from the learners through the FGDs ways in which their teachers applied Biology to everyday life through the nature of science. In all the schools visited, learners gave similar manner of applications among their teachers.

Responses from two of the schools include:

FGD Q: How does your teacher bring out the applications of Biology to everyday life during the lesson?School T

R1: our teacher, like in the topic of disease, tells us about the type of disease, how it is caused and refers to our daily life and how to prevent like washing hands before eating or after using the toilet and if in case we get the disease, helps us to take this type of medicine even if it's not mentioned in the text book.

In school T, the teacher applied the knowledge of diseases to the learners' applications in everyday life of preventing the disease such as through washing hands and if they get the disease the kind of medicine they may consume apart from what is mentioned in the text book. This was the scenario in school V:

FGD Q: How does your teacher bring out the applications of Biology to everyday life during the lesson?School V

R3: in this topic of classification, we were studying most about animals and when the teacher was teaching he used to give examples about the animals which we see in our daily lives and also he uses the things which live around us instead of using those things that we do not even have access to

R2: in the topic 'ecology' which we have just finished, we have learnt how to prevent some of the diseases we know of like typhoid and cholera and how to know the symptoms of the diseases and how it affects human beings.

In school V, apart from applying the knowledge of diseases, the teacher applied the knowledge on classification of animals to the learners by giving examples of the animals they experience in everyday life. From the instances of the applications of Biology knowledge to everyday life that the students mentioned, the teachers mainly used one aspect of the nature of science which was “the clear distinction between theory and law” in which case the teachers pointed out to the real happenings in life.

The researcher, through the class observations, sought to find out how teachers used other aspects of the nature of science in the application of Biology into everyday life.

The following are the findings:

In school U, as the teacher was explaining about the importance of reproduction, the he asks the learner to describe a dinosaur which became extinct a long time ago. The learner describes a dinosaur as a huge animal with a big tail. The learner explains that he thinks that the dinosaur was big and that was why it became extinct because it could not run away from predators. In this excerpt, the teacher uses the NoS aspect of “Give room for creativity and imagination” by asking questions that provoke the creativity and imagination of the learner in order to make the learners understand the importance of reproduction. This finding concurs with who state that employing imagination and creativity in Biology lessons improved students' understanding of scientific topics. This finding therefore may urge teachers to give room for creativity and imagination to students for them to better understand abstract scientific topics by connecting them to real-world scenarios through the use of imaginative scenarios.

In school U and T, the teachers were observed using aspect of the nature of science “Give room for socio- cultural knowledge to influence Biology knowledge” as follows:

Class observation: use of aspects of the nature of science (NoS) in application of Biology to everyday life: School U

T: in sexual reproduction, the nucleus of the sperm fuses with the nucleus of the ovum to form a zygote. Therefore another importance of reproduction is improvement of quality as the zygote has characteristics from the mother and father.

T: that is why in our communities it is strongly discouraged from marrying your relatives because you may have similar characteristics which can be perpetuated and even lead to occurrence of some mutations

In school U, the teacher applied the knowledge of Biology to everyday life by highlighting how the societal culture of not allowing marriage between relatives is important in contributing to deterrence of mutations which can lead to undesirable conditions.

In school T the teacher applied the knowledge of Biology to everyday life as follows:

Class observation: use of aspects of the nature of science (NoS) in application of Biology to everyday life: School T

T: the zygote undergoes mitotic division to form a hollow structure of several cells called blastocyst. The other thing that happens after fertilization is formation of the placenta. The placenta is also called ‘after birth’. It comes out after the baby has been born. People keep the child and throw away the placenta. But in some communities the placenta is not thrown away but buried in the compound as a sign of fertility.

In school T, the teacher highlighted how some societal cultures highly valued the placenta that even after birth it was not thrown away but buried in the home compound because it was considered a sign of fertility. This application by the teacher may help the learner understand deeply the big role the placenta plays during pregnancy and in life. These findings from school U and T concur with Bwalya

(2023) who notes that learners understand better concepts associated with their societal culture. This finding means that culture, being a way of the people in a society, its application is one of the best approaches to teach abstract concepts.

Application of Biology knowledge to everyday life through the aspect of the nature of science “Give opportunities for learners to associate Biology knowledge with realities in the society” was observed in school R as follows:

Class observation: use of aspects of the nature of science (NoS) in application of Biology to everyday life: school R

T: In treatment of diseases it is important for people to complete their dosage or else they may become resistant to such medicine. Many people once they feel better they stop taking the medicine. How many of you do that? (A number of learners raise their hands). Haven't you seen a case where one person can get cured by taking a less strong type of medicine while another cannot until they take a stronger medicine?

In school R, the teacher applied the knowledge of Biology to everyday life by highlighting the usual happenings in the social life. She mentioned that when people do not complete the dosage of their medicine, they become resistant to drugs. This application may help the learners understand why there are different drugs of different strength in the treatment of diseases. These findings from school R agree with Boudry & Pigliucci's 2018 study which noted that Biology should not be taught as some facts and truths that are not part of the society. It is therefore important to note that the society has a critical role in shaping how the study of Biology is done. Besides, it is also important to remember that Biologists are human beings who can develop biases.

From the learners' FGDs and the class observations, teachers mainly employed use of 4 out of the 8 aspects of the nature of science that the researcher sought to evaluate. The 4 aspects that the teachers used in applying Biology knowledge to

everyday life included: Give opportunities for learners to associate Biology knowledge with social realities in the society; Give room for creativity and imagination; Give room for socio- cultural knowledge to influence Biology knowledge; Guide on clear distinction between theory and law.

The other 4 aspects of the nature of science that were neither mentioned by the learners nor observed by the researcher include: Portray Biology Knowledge as tentative and not final/robust; Give room for students to use more than one method of investigation; Guide on clear distinction between observations and inferences; Identify and acknowledges names of scientists associated with the Biological discovery/knowledge. These findings imply that even though the curriculum guidelines in use are lacking the intent of use of the nature of science in applying Biology into everyday life, the Biology teachers are trying on their own to apply Biology to everyday life through some aspects of the nature of science. These findings concur with Buffalari (2022)'s study which states that even if teachers may make an attempt, the curriculum guidelines do not provide compelling rationales for, or meaningfully promote intention to application of Biology content/knowledge into everyday life context. These findings therefore show that there is insufficient use of the Nature of Science in application of Biology to everyday life. Learners may struggle to understand Biology because the use of the nature of science in application of Biology to everyday life has not been given the seriousness it deserves in the curriculum guidelines.

The researcher sought from the experts how application of Biology to everyday life through the nature of science influences the achievement of learning outcomes. The following are the responses:

KIQ: how does application of Biology to everyday life through the nature of science influence the achievement of learning outcomes? KIX

Teaching Biology as a tentative science, that is one in which concepts and hypotheses are frequently revised in light of fresh data, improves comprehension of Biology. This will also make learners want to add to the body of knowledge and therefore create or synthesize knowledge.

The key informant X stated that by portraying the knowledge of Biology as tentative, it can help the learners to comprehend Biology better and also be able to synthesize knowledge. This finding agrees with (Amoah, Emina, Ngman-Wara, & Azure, 2023) who state that teaching Biology as a tentative science improved students' comprehension of Biology and greater engagement in science as opposed to learners who were taught depicting Biology as a static and unchanging science. This finding therefore suggests that by use of the aspect of the nature of science “portray Biology Knowledge as tentative and not final/robust”, learners may achieve learning outcomes such as comprehension and synthesis. Synthesis is the highest order of cognitive learning outcomes according to the Bloom’s taxonomy.

On the same concern of how application of Biology to everyday life through the nature of science influences the achievement of learning outcomes, key informant Y had this to say:

KIQ: how does application of Biology to everyday life through the nature of science influence the achievement of learning outcomes? KIY

Through imagination and creativity, the students understand better abstract topics by connecting them to the real world. When you make Biology knowledge part of the culture of the society it makes Biology meaningful and interesting to study. When you separate real happenings from theory, it helps learners make hypothesis and evaluate concepts. When you make Biology as part of social life, the learners are able to improve their analysis-leaning outcomes. In the 8-4-4 curriculum some of these aspects are there but teachers concentrate on teaching exams. In the new CBC there also there but yet to come out clear.

The key informant Y indicated that by giving room for imagination and creativity it brings understanding of abstract concepts. This finding implies that the use of the aspect of NoS “Give room for creativity and imagination” may yield learning outcomes such as comprehension. By associating Biology knowledge with the culture of the society, learners may find Biology interesting and hence develop positive attitudes towards it. Thus, by use of the aspect of NoS “Give room for socio- cultural knowledge to influence Biology knowledge”, learners may achieve affective outcomes and positive approach to Biology. The key informant mentioned that when there is a separation of real happenings in learning from theories, the learners learn skills like making hypotheses and achieve evaluation cognitive outcomes. The informant also mentioned that connecting Biology to social life helps learners attain analysis cognitive outcomes.

These findings concur with researchers who state that students who interact with a curriculum which appreciates the nature of science gain more from the classroom and laboratory experiences and learn Biology better attaining high order cognitive, skills and affective learning outcomes (Chatzikiyriakidou, Tacloban, Concepcion, & McCartney, 2022). From these studies’ findings, one may conclude that use of the nature of science in the application of everyday life can help achieve all types of learning outcomes namely cognitive, skills and affective. Of greater value, use of NoS can facilitate achievement of high order learning outcomes such as analysis, evaluation and synthesis.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on use of NoS

From the quantitative study on use of NoS, many teachers acknowledged teaching Biology knowledge as final contrary to L'Heureux (2021)'s notion that "knowledge is neither static nor final". These findings are convergent with the qualitative study findings whereby use of NoS but still minimal. Even though there is a convergence in both the quantitative and qualitative studies on the viewpoint of all respondents that, indeed, the use of NoS plays a major role in improving learning outcomes, in practice use of Nos was only at a small extent and coincidental. This may negatively impact on students' achievement of leaning outcomes of higher levels in the long run.

4.5 Pedagogical Techniques used in Biology Teaching

Findings from the Quantitative Study on Use of Pedagogical Techniques

The third objective was to assess pedagogical techniques used in Biology teaching and its influence on the achievement of learning outcomes. In the quantitative study, the teachers who participated in the survey were presented with 11 statements depicting different pedagogical techniques and asked to indicate whether they agree with the statements. The 11 statements were:

PTBT1: Teachers should show how an experiment works (depicting demonstration method of teaching-passive)

PTBT2: Explanation of Biology facts and definitions provide core of Biology teaching (depicting explanation method -passive)

PTBT3: Well prepared lectures are efficient and for most Biology topics (depicting lecture method-passive).

PTBT4: Biology teachers have in mind specific answers to the questions they pose in class (depicting question and answer method but which is teacher centered-passive)

PTBT5: Students carry out experiments on own their own using apparatus provided (depicting experiment method-active)

PTBT6: Students work in groups make written reports of the and present their findings (depicting collaboration learning-active)

PTBT7: Students have an ongoing project in my school (depicting project method-active)

PTBT8: Biology students are provided time in class for exchanging among themselves (collaboration-(active)

PTBT9: Some time in Biology teaching is used for students to explore material question and share ideas (depicting inquiry method-active)

PTBT10: Students identify and solve real problems during Biology Classes (problem solving method -active)

PTBT11: Students are guided to find the truth about Biology themselves by independent thinking. (Depicting discovery learning-active)

Table 4.8 shows the responses on the opinion of teachers on statements depicting various pedagogical techniques.

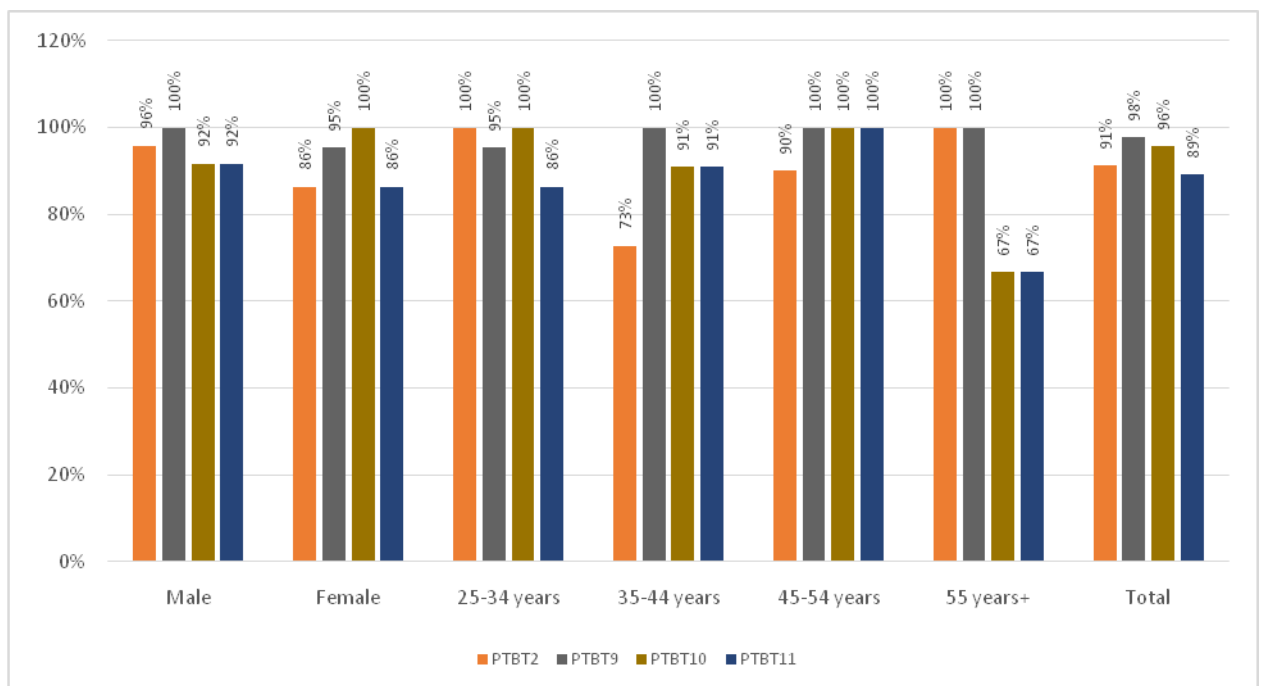
Table 4.8: Responses of Teachers on Statements Depicting Pedagogical Techniques

Teacher characteristics		PTB T1	PTB T2	PTB T3	PTB T4	PTB T5	PTB T6	PTB T7	PTB T8	PTBT 9	PTBT 10	PTBT 11
Gender	Male	79%	96%	79%	71%	75%	83%	54%	79%	100%	92%	92%
	Female	77%	86%	73%	68%	73%	86%	18%	82%	95%	100%	86%
Age	25-34 years	86%	100%	86%	68%	91%	91%	50%	82%	95%	100%	86%
	35-44 years	64%	73%	64%	73%	82%	64%	45%	82%	100%	91%	91%
	45-54 years	80%	90%	60%	70%	50%	90%	10%	80%	100%	100%	100%
	55 years+	67%	100%	100%	67%	0%	100%	0%	67%	100%	67%	67%
	Total	78%	91%	76%	70%	74%	85%	37%	80%	98%	96%	89%
Experience	4 years or less	100%	100%	100%	88%	100%	88%	75%	88%	100%	100%	100%
	5-10 years	70%	87%	65%	65%	83%	87%	35%	78%	96%	100%	83%
	11-15 years	80%	80%	80%	80%	60%	60%	40%	80%	100%	80%	100%
	16-20 years	100%	100%	0%	100%	100%	100%	0%	100%	100%	100%	100%
	21-25 years	75%	100%	75%	75%	75%	75%	25%	75%	100%	100%	100%
	30 years and above	80%	100%	100%	40%	0%	100%	0%	80%	100%	80%	80%
	Total	78%	91%	76%	70%	74%	85%	37%	80%	98%	96%	89%

For all the listed teaching pedagogies except one, above 70% of the teachers who participated in the study agreed with the statements. This finding indicates that a variation of different methods was practiced in the teaching of Biology. The one statement (Students have an ongoing project in my school) which was less agreed on was by 37% of the teachers. This means that many teachers avoided project technique in their Biology teaching. As much as project method is known to increase learning outcomes in Biology, many teachers shy away from projects because it is time consuming and requires extra cost (Buffalari, 2022). This finding therefore suggests that teachers should make efforts in utilizing project method in teaching Biology as it has been found to enhance achievement of learning outcomes. There is a need thus to plan well for projects in order to consume the available time.

Among the 11 statements concerning teaching pedagogies, four were most agreed. Figure 4.7 shows the most agreed pedagogical techniques by teachers.

Figure 4.7: Pedagogical Techniques in Teaching Biology agreed by Most Teachers



The four most agreed statements concerning teaching pedagogies included: PTBT9: Some time in Biology teaching is used for students to explore material question and share ideas, which was agreed on by 96% of the teachers; PTBT10: Students identify and solve real problems during Biology classes, agreed on by 96% of the teachers; PTBT2: Explanation of Biology facts and definitions provide core of Biology teaching, which was agreed on by 91% of the teachers while; PTBT11: Students are guided to find the truth about Biology themselves by independent thinking, 89% of the teachers.

These findings show that teachers agree that collaboration, discovery, and problem solving are pedagogical techniques which promote active learning and are key methods in teaching Biology. These findings further concur with Filmer, Molina, & Wane (2020) who states that cooperative learning and problem based approach informed by constructivist theorists increase achievement of student's learning outcomes. These findings show that Biology teachers appreciate that active learning approaches could enhance better learning in teaching Biology more than traditional teaching and learning approaches if they put them into practice. Many teachers however also agreed that explanation technique, though a passive method, is important in helping learners to understand concepts and definitions of Biology. This means that teachers may not entirely do away with passive methods of teaching but may use them accordingly to bring to context what learners experience through the active methods of teaching.

Further analysis was carried out to find out if there were any significant correlations between the characteristics of the teacher namely gender, age and experience and pedagogical technique use. Table 4.9 shows the findings.

Table 4.9: Correlation between Teacher Characteristics and Pedagogical Technique use

		Correlations													
		Gender	Age	Experi ence	PTBT 1	PTBT 2	PTBT3	PT BT4	PTBT5	PT BT6	PTBT7	PTB T8	PTB T9	PTBT 10	PTB T11
Gender	Pearson	1	.174	.088	-.023	-.168	-.075	-	-.026	.042	-.372*	.033	-.156	.204	-.085
	Correlation							.029							
	Sig. (2-tailed)		.248	.559	.880	.265	.618	.849	.865	.781	.011	.826	.301	.174	.574
	N	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Age	Pearson	.174	1	.834**	-.125	-.121	-.128	.008	-.540**	.005	-.362*	-.066	.134	-.249	.025
	Correlation														
	Sig. (2-tailed)	.248		.000	.407	.423	.397	.955	.000	.971	.014	.661	.376	.096	.869
	N	46	46	46	46	46	46	46	46	46	46	46	46	46	46
Experi ence	Pearson	.088	.834**	1	-.043	.084	.046	-	-.536**	.028	-.359*	-.033	.064	-.249	-.028
	Correlation							.168							
	Sig. (2-tailed)	.559	.000		.779	.580	.761	.263	.000	.854	.014	.829	.671	.095	.852
	N	46	46	46	46	46	46	46	46	46	46	46	46	46	46

*. Correlation is significant at the 0.05 level (2-tailed).

** . Correlation is significant at the 0.01 level (2-tailed).

Male teachers, younger teachers and teachers with less teaching years agreed with PTBT7 (having students with an ongoing Biology project in school). Younger teachers and teachers with less years of experience also agreed with PTBT5 (students carry out own experiments using apparatus provided). This finding agreed with other studies which indicate that younger and recently trained teachers tend to put into practice methods and skills they have learnt. This finding establishes that there may be challenges that a teacher comes along with in the course of teaching which pose a barrier to using active methods of teaching Biology.

After determining how active pedagogy was used, the researcher sought to find out how active pedagogy influences achievement of learning outcomes. In the quantitative study the Biology teachers who participated in the survey were asked to indicate on a scale of 1-5 (1 lowest rate and 5 highest rate) how useful they found the various statements on pedagogical teaching techniques regarding achievement of learning outcomes.

Table 4.10 shows the responses about the usefulness of the various teaching techniques in achievement of learning outcomes.

Table 4.10: Pedagogical Techniques on Achievement of Learning Outcomes

Rating		PTB TR1	PTB TR2	PTB TR3	PTBT R4	PTB TR5	PTB TR6	PTB TR7	PTB TR8	PTB TR9	PTBT R10	PTB TR11
Gender	Male	3.88	4.21	4.00	3.79	4.17	4.21	3.96	4.17	4.33	4.25	4.46
	Female	4.00	4.23	3.55	3.77	4.14	4.27	3.55	4.09	4.36	4.27	4.50
Age	25-34 years	4.14	4.36	4.23	4.00	4.45	4.32	4.05	4.18	4.32	4.41	4.45
	35-44 years	3.64	3.64	3.55	3.82	4.27	4.36	4.00	4.36	4.45	4.18	4.45
	45-54 years	4.10	4.40	3.10	3.60	3.40	3.80	3.00	3.70	4.40	4.10	4.60
	55 years+	3.00	4.67	3.67	2.67	4.00	4.67	3.33	4.33	4.00	4.00	4.33
Experi ence	4 years or less	4.38	4.25	4.13	4.13	4.50	4.63	3.88	3.88	4.25	4.25	4.38
	5-10 years	3.91	4.26	3.78	3.96	4.22	4.30	3.91	4.30	4.48	4.43	4.57
	11-15 years	3.60	3.20	3.80	4.00	4.00	4.00	3.60	4.00	4.00	4.00	4.00
	16-20 years	5.00	5.00	1.00	2.00	5.00	3.00	2.00	4.00	4.00	5.00	5.00
	21-25 years	3.75	4.50	3.50	3.75	4.00	4.25	4.25	4.50	4.50	4.50	4.75
	30 years and above	3.60	4.60	4.00	2.60	3.40	3.80	3.00	3.60	4.20	3.40	4.40
	Total	3.93	4.22	3.78	3.78	4.15	4.24	3.76	4.13	4.35	4.26	4.48

Six out of 11 of the pedagogical techniques were rated as considerably useful to very useful in contributing to high achievement of learning outcomes. These included: discovery, collaborative, inquiry, problem solving, group discussion, explanation and experimentation techniques. Guiding of students to find the truth by independent thinking which is discovery learning was the highest rated in terms of usefulness, with 4.48 out of 5. Other than the explanation method which is a passive method, teachers are agreeing that active methods are what may contribute to the high achievement of learning outcomes. These findings agree with Filmer, Molina & Wane (2020) who note that pedagogical techniques encourage active learning and

therefore enhance achievement of learning outcomes. This finding shows that teachers understand the usefulness of active pedagogy but from the earlier findings of this study through class observations and learners' FGDs active methods are scanty in Biology lessons. One is left to wonder why teachers understand the usefulness of recommended methods and yet do not practice adequately.

The lowest rated pedagogical technique was that of having students with an ongoing Biology project in school, rated at 3.76 out of 5 in usefulness. This notion by Biology teachers is contrary to the findings by Filmer, Molina, & Wane (2020) who recommend the project method as being a useful technique which enhances active learning and consequently high achievement of learning outcomes. These findings therefore imply that Biology teachers are yet to embrace and practice pedagogical techniques which encourage active learning. It seemed that there were challenges that teachers could be facing or rather some reasons as to why Biology teachers were not fully exercising learner centered methodologies. This study however did not go further to unearth the reasons behind insufficient usage of the recommended active pedagogy in Biology teaching.

Findings from the Qualitative Study on Use of Pedagogical Techniques

In the qualitative approach to assessing pedagogical techniques used in Biology teaching, the researcher found out how both active and passive pedagogical techniques were used in Biology teaching. The researcher sought to establish from the key informants the place of active pedagogy in Biology teaching. Key informant W had this to say:

KI Q: How should teachers use active pedagogy in teaching Biology? KI W
We recommend inquiry Based Learning (IBL). At the stage of lesson planning, a teacher should plan and develop critical questions called the key inquiry questions which as you have seen have been adopted by the CBC. It

is good always to pause so that learners can be able to think and maybe interact, discuss rather than giving content and later on you want to ask a question. We have trained some teachers about the 5e instructional approach that a lesson unfolds. Like how do you i) engage learners, they are many ways. You can use the key inquiry question, you can do a small maybe demonstrations then you can ask them a question and then from there you need to plan for the ii) experiences for the learners to do or explore so that's where now the hands on and the minds on come in. and when they are doing the hands on let them iii) explain their findings. After explaining can it be seen from another concept? that is application. iv) extension, you know, can they be able to use it to a new situation? Whatever they have learnt. Then the aspect of v) evaluation. Involves testing if the learner has understood the concept. IBL ensures the learner is involved at every stage. Of course there are other active methods like projects, problem solving and whatever but mainly all of them involve the learner being the centre

Key informant W explains how active methods may be used, indicating that they should be planned right from the lesson planning. In particular, the key informant W describes the Inquiry Based Learning (IBL) approach. In this approach the key informant discussed the 5e instructional approach. The first e is engage, where the teacher may use a key inquiry questions or demonstrations. The second e is experiences that the learner should explore to be able to solve the inquiry question. This stage of experience should involve hands on activities. The third e is about explaining. Here the learners need to report and explain their findings. The fourth e is extension. Here the learners need to apply their findings in new situations. The fifth e is evaluation. Evaluation involves testing if the learner has understood the concept.

The key informant therefore emphasized on inquiry-based learning, problem solving, project based learning and methods which put the learner at the center. On the same question of active pedagogy, key informant X had this to say:

KI Q: How should teachers use active pedagogy in teaching Biology?KIX
The flipped method. What does it mean? Students are given what to do in the next lesson. They prepare and after preparation they discuss among themselves in the class during the lesson and the teacher is not a know it all.

The teacher should become a facilitator. But if the teacher say we have stopped here and we shall continue from there. You have not given them assignment to go and find out the knowledge. si it is the teacher who has said they will start from there? Let them go and do research and then they discuss. As a teacher; as a facilitator, you should say so and so from this group said this and this but it is supposed to be this way. it is going to promote learning. And that is why we have things like projects and key inquiry assignments for learners to research.

Key informant X emphasized on the need of the learner to be given in advance what to do in the next lesson. The learner either as an individual or in a group should prepare and then during the lesson present to the rest. The teacher should only be a facilitator and not a know it all. The work of the teacher should be to make clarifications if learners do not explain as they should. Key informant X discouraged the teacher from stating that they have stopped somewhere and that they will start from there as this discourages further learning. The key informant X proposed other active methodologies such as projects and key inquiry assignments.

The key informant X similarly, just as key informant W, emphasized on inquiry-based learning, project-based learning and methods which put the learner at the center. These findings from the key informants are in agreement with finding from studies like the study by Filmer, Molina & Wane (2020) which states that pedagogical techniques encouraging active learning are to be embraced in teaching Biology. These findings therefore show that learner centered pedagogy is the most recommended in the teaching and learning Biology.

The researcher sought to find out how teachers used active pedagogical techniques during Biology lessons from the learners through the FGDs. The learners had this to say:

FGD Q: Describe how your teacher often takes you through a Biology lesson from the beginning to the end of the lesson school Q

R4: Our teacher usually starts with reviewing the last lesson. He then introduces the new concept. He asks us questions of the topic because he expects us to have read earlier. He clarifies hard questions and gives us more questions at the end of the lesson.

R2: We read further using textbooks and make our own notes.

R3: Our teacher rarely puts us in groups in class but we do our own discussion groups

R5: Discussion groups are good because you are free to ask your peers a question which you might fear asking the teacher in class

Q. do you have an ongoing Biology project for your class?

All: No

The learners in school Q described that their teacher began their lesson by reviewing the previous lesson; the teacher then introduced a new concept in the new lesson by asking questions because the teacher expects learners to have read earlier. The teacher then explained the topic and gave more questions at the end of the topic in preparation for the next topic. The learners also mentioned that they had their own discussion groups but had no Biology project ongoing.

The main featuring of active pedagogy that came out from the learners' FGD is the key question that the teacher asked the learners to prepare in advance. There was also an attempt of collaboration learning through group discussions but this is more of an initiative of learners. These findings agree with Clark & Hsu (2023) who state that some teachers make attempt to employ active pedagogy in their teaching but seem to have constraints. One may conclude therefore that the teacher in school Q made attempt to utilize learner centered methods which encourage active learning. The use of active methods was however not sufficient because, in most parts of the lesson, the teacher featured more than the learners. More effort to move towards active pedagogy should therefore be sought. The students saw the need of collaboration learning and had formed their own groups which were not initiated by

the teacher. This means that learners embrace active methods of teaching and may want their teachers to engage them more.

The researcher observed how active pedagogy was used in school Q as follows:

Class observation: The place of active pedagogy: School Q

T: Remember last time we dealt with parts of the eye. Today I want us to talk about image formation and vision interpretation. the key question was. 'describe image formation and vision interpretation'.

L3: The light enters the cornea. From the cornea it is focused on the lens, then to the retina which is full of cons and rods.

T: You remember the role of cons and rods?

All: yes

L3: NOTE that the image is formed as small and inverted on the retina. Then the photoreceptors at the retina send impulses to the brain via the optic nerve. In the brain the image is interpreted as upright and of the right size.

Just as the learners in school Q had indicated in the FGDs, the only active pedagogy the researcher observed in the lesson is the key inquiry question which had been given in advance. During the lesson, one of the learners discussed the key inquiry question which he had prepared. This shows that use of active pedagogy was minimal which means that the advice of researchers and experts about methods of teaching Biology was not being followed adequately. It is therefore feared that achievement of learning outcomes in Biology may be affected negatively.

In school R, S, T, U and V, no features of active pedagogy were discussed in the FGDs nor observed by the researcher. These findings showed that the recommended active learning methods were missing in action. These findings agree with Mbatia et al (2020) who espouse that, in Kenya, contrary to the recommended active learning pedagogy, teacher centered methods of instruction dominate science classroom practices. This finding is pessimistic given that learners have continuously

performed dismally in Biology (KCSE 2012-2023 reports) and yet the recommended active pedagogical techniques are not being utilized in the classrooms.

With the qualitative approach, the researcher sought from the key informants how use of active pedagogy influenced achievement of learning outcomes. The key informants had this to say:

KIQ: how does use of active pedagogy influence the achievement of learning outcomes? KI W

High order learning outcomes such as analysis, evaluation and synthesis is what we get when we focus on learner centered methods like Inquiry Based Learning (IBL), so teaching as inquiry or learning as inquiry.

Key informant W stated that use of active pedagogy in Biology help learners to achieve high order cognitive learning outcomes such as analysis, evaluation and synthesis. Key informant X had the following about the same:

KIQ: how does use of active pedagogy influence the achievement of learning outcomes? KI X

All those active learning pedagogy encourage high order cognitive learning, also skills such as observation, experiment and hypothesis learning. Active pedagogies also promote positive attitudes towards learning Biology.

Key informant X showed that active pedagogy promotes achievement of high order cognitive incomes; also in the achievement of skills outcomes such as observation, experiment and hypothesis making skills. In addition, active pedagogy also promotes affective outcomes such as enhancing positive attitude.

From the key informants, active pedagogy enhances achievement of high order cognitive outcomes such as evaluation, analysis and synthesis; skills outcomes such as observation, experiment, hypothesis making; and affective outcomes such as positive attitudes towards learning Biology. These findings concur with researchers' Tarusha & Gjuzi (2024) findings who note that active learning such as problem-based instruction is an effective approach for teaching higher-level thinking processes requiring learners to evaluate and synthesize knowledge since it promotes

inquiry learning and hence helps students construct their own knowledge. Given that in this study's findings, there was inadequate use of active pedagogy in Biology teaching, it means that learners rarely achieve higher order learning outcomes such as analysis, evaluation and synthesis. These higher order learning outcomes are what may help scholars initiate innovations and solutions to societal problems as the Kenya Vision 2030 aims to. There is therefore a need for interventions to emphasize on active teaching methods as recommended by researchers.

After establishing the place of active pedagogy in Biology teaching, the researcher went ahead to also seek from the Key Informants the place of passive pedagogy in Biology teaching. Key informant X noted this:

KI Q: How should teachers use passive pedagogy in teaching Biology? KIX
Passive pedagogy like lecture method, question and answer is wrong transfer of concepts leading to failure. However, some explanation and demonstrations would be useful but should not take centre of the learning. But then even if it is question and answer they should be open ended leaving learners to think wide. Not those ones which the teacher has known answers already and learners only need to recall.

Key informant X discouraged passive pedagogy because according to the informant, it is wrong transfer of concepts. He indicated that some methods like explanation and demonstration may be used but should not take the center of the learning process. Methods like question and answer should be open ended and not the kind of questions with known answers requiring the learner only to recall.

Key informant W, on the same concern about use of passive pedagogy, had this to say.

KI Q: How should teachers use passive pedagogy in teaching Biology? KIW
We discourage Passive pedagogy because it mainly promotes rote learning. However, for instance, for risky experiments or where apparatus are few, the teacher may use demonstration method. But even in the demonstration the teacher should involve the students as much as possible. For new concepts, a

teacher may use explanation before engaging the learners to experiment and research.

Key informant W, just like key informant X, discouraged passive pedagogy. The informant stated that some passive methods like demonstration may be used to illustrate risky experiments or in a situation where the apparatus are few. KIW also noted that a teacher may use explanation method to introduce new concepts before engaging the learners further.

These findings agree with Mbatia et al (2020) who warns that teacher centered methods should be discouraged because they often give a pseudo impression that effective learning has taken place as implied. These findings show that the place of teacher centered methods which promote passive learning should be minimal. It is unfortunate however because the findings of the current study showed a contrary state whereby the teacher centered methods dominated the Biology lessons instead.

The researcher further sought to find out how teachers use passive pedagogical techniques from the learners through the FGDs. The learners had this to say:

FGD Q: Describe how your teacher often takes you through a Biology lesson from the beginning to the end of the lesson: School V

R3: The teacher enters the classroom greets us then summarizes the last topic. After summarizing, he asks some questions. Then we continue with the new topic.

R4: After the teacher introduces that topic he mostly dictates for us notes. at the end he asks us a few questions and ends the lesson.

The learners in school V indicated that their teacher after greeting them summarizes the last topic. The teacher then asks a few questions from the last topic and introduces a new topic. The teacher dictates notes and towards the end asks a few questions.

The researcher then observed a lesson in school V and this is how it went:

Class observation: The place of passive pedagogy: School V

T: Good morning. In our last lesson we talked about the parasite Ascaris lumbricoides that is the roundworms.

T: What are the two hosts of Ascaris lumbricoides? Yes L1

L1: Man and pig.

T: What are the adaptive features of Ascaris lumbricoides?

L2: They are thin to fit in the intestines.

T: Yes. You can read more about the other adaptations. (pause). Today we will be talking about schistosoma (writes on the board, dictates notes on schistosoma mentioning the host of schistosoma, its adaptive features, how its spread and prevention measures. (The teacher writes the difficult words on the board.) Now answer the following questions. (writes questions on the board). Tomorrow we have a CAT. Make sure you revise. We have come to the end of our lesson.

Just as the learners in school V had indicated in the FGD, their teacher after greeting the them reviewed the last lesson by doing a summary. The teacher asked a few questions from the last lesson and then introduced the new concept for the day's lesson. The teacher dictated notes on the new concept and gave questions at the end of the lesson.

From the learners FGD and the class observation in school V, the domineering teaching methods in school V included: lecture method and question and answer method of which both are passive methods. The teacher was dominant in the class discourse. The scenario in school V was similar to school U and T. This finding shows that the teacher centered methods were not just domineering in Biology lessons but were the only methods used in some schools across the teaching and learning subjects.

In school R and S, the teachers' teaching approaches were more or less similar but different from school Q, U, V and T. The lessons went as follows in school S and R according to student FGDs:

FGD Q: Describe how your teacher often takes you through a Biology lesson from the beginning to the end of the lesson

School S

R2: When she comes to class, greets us, introduces new topic and explains.

R1: She give us notes then we read from KLB to add more.

R3: After the topic we watch a video; we discuss the video

R1: She gives us assignment after the lesson

School R

R1: She projects every lesson. we are able to see and then she explains it to us. After greeting us, she plays a video and explains it further. Now we are able to see and understand. You know when you are taught something and it is just theory it becomes monotonous. But when you are exposed to videos and what is happening, you are able to remember.

R3: She really teaches well. She explains the videos and gives us examples of real experiences in life.

R4: She teaches in a unique way unlike some teachers who like want to fix information in your head instead of making you to understand the concept. R5: Emphasizes on KCSE concepts such as writing the correct spelling.

In schools R and S, their teachers projected and played videos during the lesson. In school S, the teacher gave notes and learners read from the textbooks to add to any other notes. After explaining and giving notes, the teacher played a video and explained it to the learners. The teacher in school S then gave assignment to the learners. In school R, the teacher played a video and after that explained the concepts in the video. She explained in a unique way and brought the realities to the learners' understanding rather than force learners to understand information. The learners in school R also appreciated that their teacher emphasized on KCSE question and correct spelling of biological terms. In both school S and R, the following methods came out: question and answer, demonstration through video and explanation. In both schools, there was an attempt to involve the learners through demonstrations and videos but still the teacher centered methods majored.

The researcher then observed a lesson in school R which went thus:

Class observation: The place of passive pedagogy: School R

T: watch the video on the screen... What are the adaptive characteristics of ascaris lumbricoides?

L: Thin to fit in the host's intestines

T: There are two more points remaining...

T: How can you prevent ascaris lumbricoides?

T: What are the two forms of snails that cause schistosoma? note the spelling. emphasized.

T: (teacher writes questions down) These are some past KCSE questions. attempt by the next lesson.

The teacher in school R begins by displaying a video after which she asks questions regarding the video and explains to the students. The teacher then gives past KCSE questions about the topic for assignment. The teacher was keen on the spelling of biological terms. The methods of teaching that dominated include: demonstration through the video, explanation and question and answer methods. The teacher dominated the talk throughout the lesson. The findings from the class observations concurred with the learners' FGD in school R. It seemed that their Biology teacher was keen on preparing learners for summative evaluation (KCSE) more than engaging in active pedagogical methods like problem solving, group discussions and inquiry-based learning. Perhaps these learner-centered methods were avoided as they would consume a lot of time at the expense of the time needed to prepare for examinations.

From the FGDs and class observations in schools R,S,T,U and V, passive methods of teaching were the center of teaching. No active methods of teaching were observed during the lessons or discussed in the FGDs. These findings are in sync with the findings from a study by (Superfine, Ko, & Goldman, 2022) who state that despite the knowledge of the usefulness of active methods in Biology teaching and learning, teacher centered methods of instruction, and especially the lecture, question and answer and explanation methods, dominate Biology classroom practices. This

finding is defeatist because just as many researchers have reported that there is lack of practice of learner centered methods in Biology classrooms, the findings of this study similarly find the same scenario. What is even worrying is that teachers are aware that active methods may yield higher learning outcomes, but are somehow unable or unwilling to fully implement the preferred learner-centered methods.

In the qualitative approach, the researcher sought from the key informants how use of passive pedagogy influence achievement of learning outcomes. The key informants had this to say:

KIQ: how does use of passive pedagogy influence the achievement of learning outcomes? KIX

All those passive methods encourage rote learning and memorization. Those methods can only help learners achieve low order cognitive outcomes such as recall and at most understanding. This kind of learning also brings fatigue to learners causing them to get disinterested. You cannot expect achievement of skill outcomes from passive methods. If a teacher is very good in explaining and demonstration, learners may understand via explanation and may be develop observation skills through demonstrations and observing videos.

The key informant X stated that use of passive pedagogy encourages rote learning and memorization so learners can only achieve low order cognitive outcomes such as remembering. If the teacher is very good in explaining they may achieve understanding learning outcomes. If the teacher uses demonstrations and videos, the learners may achieve understanding outcomes and also develop observation skills. For affective outcomes, the key informant said that passive pedagogy makes learners to be bored and may therefore develop a negative attitude to learning Biology. From these findings, learners may never achieve higher order learning outcome with passive methods being the center of learning in Biology classrooms.

On the same note the key informant W said the following on how passive pedagogy influenced achievement of learning outcomes:

KIQ: how does use of passive pedagogy influence the achievement of learning outcomes? KIW

With passive pedagogy in Biology we can only achieve low order cognitive outcomes. Unfortunately, it is what is happening in most schools. It gives a wrong impression that learning has occurred. Efforts should be made to change this practice and move towards active pedagogy.

The key informant W informed that the only learning outcomes that learners can achieve from passive pedagogy are low order cognitive outcomes. The informant indicated that it was unfortunate that passive pedagogy was the common practice which gave an impression that learning has happened while in the actual sense it hasn't and therefore advised a change towards active pedagogy. These findings agree with the findings of Mbatia et al (2020) who note that passive instruction is designed to promote student rote learning; just requiring learners to remember concepts. These findings therefore indicate that for effective learning and achievement of higher order learning outcomes, passive methods of teaching should only play a subsidiary role to the learner centered methods of teaching.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on Pedagogical Techniques

In both the quantitative and qualitative studies, the dominant aspect was that teachers shied away from projects either due to time constraints or cost implication. Divergence, however, appeared on the aspect of collaboration learning whereas while the quantitative study portrayed high collaboration learning, the qualitative study indicated that learners initiated the collaboration by themselves. This is in tandem with Buffalari, (2022) who states that passive teaching methods should only complement already-established learner-centered methods of teaching.

4.6 Use of ICT Integration in Biology Teaching

The fourth objective was to examine the integration of ICT in Biology teaching and its influence in the achievement of learning outcomes.

Findings from the Quantitative Study on Use of ICT Integration in Biology Teaching

The teachers who participated in the survey were presented with nine statements. The first five depicted different ways of integrating ICT in teaching Biology and the other four based on why teachers do not use ICT. The teachers were asked to indicate whether they agree with the statements regarding integrating ICT in teaching Biology. The nine statements were:

ICTIBT1 Teachers encourage and allow learners to use digital tools such as computers, phones for further information/ research

ICTIBT2 Teachers use ICT in class to show biological processes in the classrooms.

ICTIBT3 Teachers use ICT to project notes for students.

ICTIBT4 Teachers keep and retrieve information records using ICT.

ICTIBT5 Teachers carry out assessment of learning with ease and speed using computer technology

ICTIBT6 Teachers do not use ICT due to lack of facilities

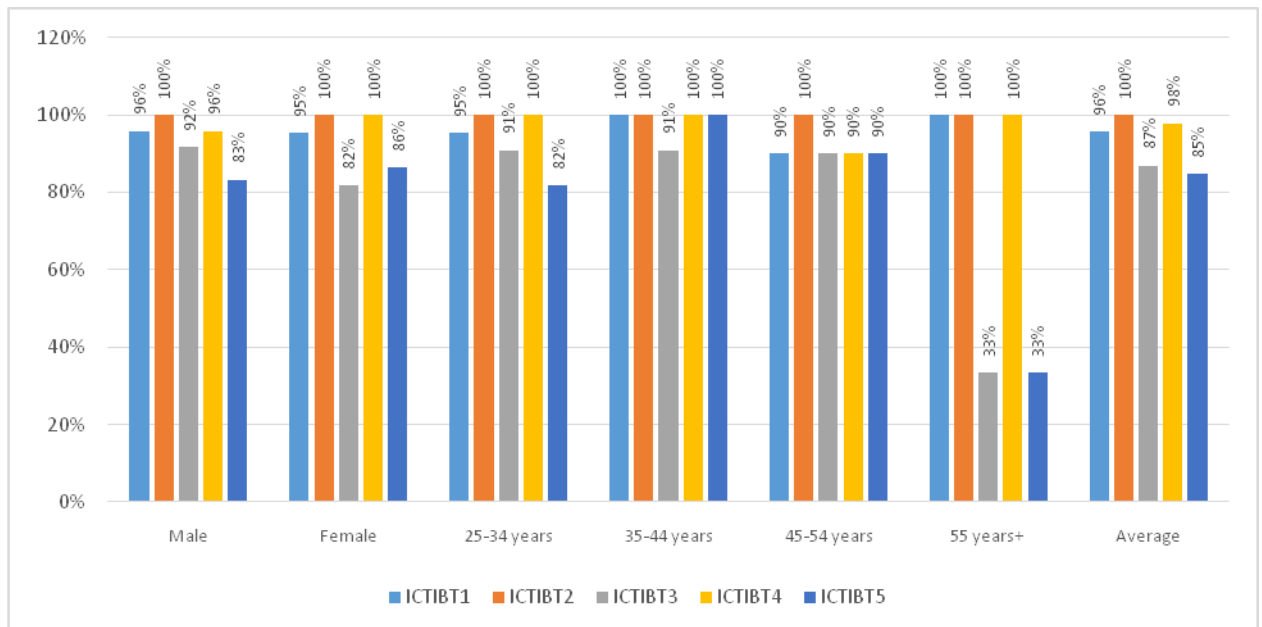
ICTIBT7 Teachers do not use ICT due to lack of training/know how

ICTIBT8 Teachers do not use ICT due to time constraints

ICTIBT9 Teachers, even though there is availability of time and ICT facilities, ignore to use ICT

Figure 4.8 shows responses on use of ICT by Biology Teachers.

Figure 4.8: Integration of ICT in Biology Teaching



All teachers who participated in the study agreed that teachers use ICT to show biological processes in the classroom. Most of the teachers (98%) agreed that Biology teachers keep and retrieve information records using ICT while 96% of the respondents agreed that they allow learners and encourage them to use digital tools such as computers and phones for further research. A good number, 87%, agree that teachers project notes for learners using ICT. Many teachers, 85%, agreed that teachers carry out assessments using ICT. These findings indicate that there Biology teachers acknowledge and agree with the integration of ICT as the teachers rated high various ways of ICT use ranging from 85%-100%. These findings concur with Mbat, Wanjala, & Edome (2020) who state that many teachers in Kenya are open to incorporating ICT into their teaching methods. Teachers therefore recognized the potential of ICT integration in enhancing learning and improving information access.

Further analysis was carried out to find out if there were any significant correlations between the characteristics of the teacher namely gender, age and experience and ICT use.

Table 4.10 shows the correlation between the teacher characteristics and ICT use.

Table 4.11: Correlation between the Teacher Characteristics and ICT use

		Correlations											
		Gende		Experie	ICTIB	ICTI	ICTI	ICTI	ICTI	ICTI	ICTI	ICTI	ICTI
		r	Age	nce	T1	BT2	BT3	BT4	BT5	BT6	BT7	BT8	BT9
Gender	Pearson	1	.174	.088	-.009	. ^a	-.146	.143	.042	.210	.073	.109	-.124
	Correlation												
	Sig. (2-tailed)		.248	.559	.951		.333	.344	.781	.162	.629	.471	.411
	N	46	46	46	46	46	46	46	46	46	46	46	46
Age	Pearson	.174	1	.834**	-.029	. ^a	-.252	-.174	-.119	-. ^{298*}	.022	.002	-.062
	Correlation												
	Sig. (2-tailed)	.248		.000	.850		.091	.248	.429	.044	.884	.989	.683
	N	46	46	46	46	46	46	46	46	46	46	46	46
Experience	Pearson	.088	.834**	1	.092	. ^a	-.288	-.222	-.127	-.243	.098	.063	.089
	Correlation												
	Sig. (2-tailed)	.559	.000		.543		.053	.138	.399	.104	.517	.679	.555
	N	46	46	46	46	46	46	46	46	46	46	46	46

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Among the nine statements, there was a significant correlation between age and ICTIBT6 use (Teachers do not use ICT due to lack of facilities). Younger teachers agreed that lack of ICT use is due to lack of facilities. These findings agree with the study of Admire & Patience (2024) who reveal that younger teachers are more likely to use ICT in their teaching than older teachers if the facilities are available. These findings show that with availability of ICT facilities many teachers especially the young may utilize ICT in teaching. It could also be because probably the younger teachers may have the knowhow of using ICT compared to older teachers.

After establishing how ICT integration was happening in the selected schools, the researcher sought to establish how ICT use influences achievement of learning outcomes. With the quantitative approach, the teachers were asked in a scale of 1-5 (1 lowest and 5 highest) to indicate the extent to which various uses of ICT contribute to the achievement of learning outcomes. Table 4.12 shows the extent to which ICT integration contribute to achievement of learning outcomes.

Table 4.12: Extent ICT Integration Contributes to Achievement of Learning Outcomes

Rating		ICTIBTR1	ICTIBTR2	ICTIBTR3	ICTIBTR4	ICTIBTR5
Gender	Male	4.67	4.50	4.46	4.50	4.25
	Female	4.41	4.32	4.00	4.18	3.95
Age	25-34 years	4.68	4.45	4.27	4.45	4.23
	35-44 years	4.27	4.27	4.09	4.27	4.09
	45-54 years	4.60	4.60	4.50	4.50	4.10
	55 years+	4.33	4.00	3.67	3.33	3.33
Experience	4 years or less	4.50	4.38	4.13	4.13	4.25
	5-10 years	4.61	4.43	4.26	4.52	4.09
	11-15 years	4.00	4.00	4.00	4.00	3.80
	16-20 years	5.00	5.00	5.00	5.00	5.00
	21-25 years	4.75	4.75	4.50	4.50	4.25
	30 years and above	4.60	4.40	4.20	4.00	4.00
	Average	4.54	4.41	4.24	4.35	4.11

The Biology teachers who participated in the study across all genders, ages and years of teaching experience, on average, rated the ICT integration highly (4.11-4.54 out of 5) as considerably useful in contributing to the achievement of learning outcomes. Encouraging learners to use ICT such as phones was rated highest at 4.54, followed by use of ICT to demonstrate biological processes. Projection of notes and diagrams was rated at 4.35 while keeping and retrieving information was rated at 4.24. Use of ICT in assessment was rated at 4.11 which was the lowest compared to the rest. These findings agree with (Belay, Khatete & Mugo, 2020) who encourage use of ICT to engage students, enhance interactive learning experiences, improve information access and hence improve on achievement of learning outcomes. These findings show that many teachers recognized the usefulness of ICT integration even

though, through class room observations and learners' FGD, minimal ICT use was witnessed. This implies that only a few learning outcomes may be achieved via the use of ICT in the schools under study and yet researchers have documented the huge impact of learning outcomes that can be attained if ICT was well used.

The researcher sought to find out the reasons why teachers do not integrate ICT despite its usefulness. The teachers were presented with four statements depicting statements why teachers do not use ICT and asked to rate them in a scale of 1-5 (1 being the lowest rate and 5 the highest).

- ICTIBT6 Teachers do not use ICT due to lack of facilities
- ICTIBT7 Teachers do not use ICT due to lack of training/know how
- ICTIBT8 Teachers do not use ICT due to time constraints
- ICTIBT9 Teachers even though there is availability of time and ICT facilities ignore to use of ICT

Table 4.13 shows the reasons why Biology teachers do not integrate ICT in their teaching according to the quantitative study.

Table 4.13: Reasons for Non-Integration of ICT by Biology Teachers

Gender		ICTIBT6	ICTIBT7	ICTIBT8	ICTIBT9
Age	Male	75%	71%	63%	67%
	Female	91%	77%	73%	55%
Experience	25-34 years	95%	73%	68%	64%
	35-44 years	73%	73%	64%	64%
	45-54 years	70%	80%	70%	50%
	55 years+	67%	67%	67%	67%
	4 years or less	100%	100%	88%	75%
	5-10 years	83%	57%	52%	48%
	11-15 years	80%	80%	80%	80%
	16-20 years	100%	100%	100%	0%
	21-25 years	75%	100%	100%	100%
	30 years and above	60%	80%	60%	60%
Average		83%	74%	67%	61%

Most teachers, 83%, agreed that teachers do not use ICT due to scarcity or lack of ICT facilities, 74% of the teachers agreed that they do not use ICT due to lack of knowhow, 67% noted that they do not use ICT due to time constraints while 61% of the teachers who participated in the study agreed that teachers just ignore using ICT. These findings agree with other researchers (Belay, Khatete & Mugo, 2020) who identified the factors that were hindering the ICT Utilization as lack of power supply, insufficient resources, fear of technology, lack of interest, ICT skills deficiency, higher ICT cost and poor physical infrastructure. These findings show that lack of facilities and infrastructures were the main reason why teachers failed to use ICT. This means that teachers could be willing to integrate ICT if provided with facilities.

Findings from the Qualitative Study on Use of ICT Integration in Biology Teaching

From the qualitative approach, the researcher sought from the key informants on how ICT should be used by teachers in the teaching of Biology. The following is the response from key informant X:

KIQ: How do you advise teachers to integrate ICT in Biology teaching?

KI X

Most people think that ICT integration is computer; it is only one of the components of ICT. Information can be generated by any object and this information generated can be communicated in any way e.g. using a lap top, a phone etc. a computer cannot be used alone in ICT integration. A computer, a projector and a screen, those three form one technology in teaching and we call it a white board. A white board is made of three components. One must choose a technology and plan how they will infuse during teaching. Even within one technology like the white board, there are several ways of application. A teacher can integrate their lessons with animations and simulations. Animation is taking whatever you are teaching which is static to be in motion for example. What do you know about animals? They move so if I was talking of a skeleton in animals they can see it moving in animation. When we talk of simulation we create a situation to look really in the eye of the learner. this is suitable for explaining processes like you can teach photosynthesis what happens in the leaf and how the food

is manufactured and how it is transported and stored in areas using simulation. That is more encouraged than theoretically.

The key informant X informant indicated that many people do not understand what ICT integration means and that it actually means information generation and communication by use of any object not necessarily a computer and infusing it in the teaching process. The key informant X further indicated that ICT integration involves choosing a technology and planning to use it during teaching. This description of ICT integration by the key informant X agrees with Zaman, Ghosh, Majumder, & Chakraborty (2025) who note that ICT integration involves the intentional Utilization of technology to enhance teaching activities, promote student engagement and facilitate access to information. This means that lack of understanding of ICT use in the first place is a deterrent to proper use of ICT in teaching and learning Biology.

The key informant X further stated that a computer is often used with a projector and a screen to form one technology called a white board. The informant indicated that there are several ways of applying technology, one being animation. The key informant X said that animation is taking a static object and illustrating it to be in motion, for example, instead of teaching using a static skeleton the learners can instead see the skeleton moving in animation. Another way of ICT application is use of simulations. The key informant X described simulations as creating a situation to look real. Simulations are good in explaining processes such as photosynthesis and are much encouraged than theories. Thus, the key informant X noted that animation and simulations are ways of using ICT. These findings shed light on how ICT may be used to facilitate learning. However, from the earlier observations, none of these applications of ICT were displayed. The only two schools whose teachers were

observed using ICT used it mainly for displaying videos and for learners to view diagrams.

On the same concern about how ICT should be used by teachers in the teaching of Biology, the key informant W said the following:

KIQ: How do you advise teachers to integrate ICT in Biology teaching?

KI W

They can do simulations in situations where they might not have the materials or some of the risky kind of experiments. We have shared with teachers the process of making nice ICT integrated lessons because it is not just a matter of showing videos and whatever. So we give them a matrix that we normally use with the teachers. I want to teach concept A. This concept A which digital and non-digital tools do I use? And in the same matrix you have to answer why do I need these resources? When do I use these resources in the lesson? When and where? Are you going to use it as a setter for engagement? Are you going to use it for them to explore and maybe gather some data and maybe explore and make conclusions? Are you going to use it to summarize the lesson? Or to assess learner's? So we have taken them through that and then to make your presentation.

Key informant W indicated that teachers may use ICT integration for simulations like in the case of risky experiments. The informant was categorical that ICT integration is not just a matter of showing videos but rather the teacher should make a good choice of technology whether digital or non-digital and when and where it should be used. He informed that ICT integration may be used as a setter for engagement; for the learners to explore and make conclusions or for assessment or making a presentation. These findings from both key informant W and X agree with (Admire & Patience, 2024) who document that use of Information, Communication Technology (ICT) in delivery of instruction such as simulations, learner engagement and exploration has a huge positive impact on learning. Use of ICT for the purposes outlined by the researchers and key informants was however lacking in the schools

of study. This finding is discouraging given the positive impact ICT may bring in the learning of Biology.

The researcher sought from learners through FGDs how their teachers use ICT integration. The following are some of the responses.

How do you and your teacher use ICT during the Biology lesson? School Q

R3: The teacher projects videos for us to see.

R5: Also to view some complex diagrams.

R1: He has some questions in his lap top which he asks us

In school Q, the learners mentioned that their teacher used ICT integration by projecting videos for them to see, displayed complex diagrams and stored some questions in his laptop which he asked during the lesson. Thus the teacher used ICT to engage and also to assess the learners, but on the two days the researcher visited the school, the teacher did not use any ICT integration during the teaching process.

In school T, the learners reported the following:

How do you and your teacher use ICT during the Biology lesson? School Q

R2: The teacher sometimes comes with the laptop and his phone but sometimes he can come with the projector and project it on the wall and it shows us videos. Then he asks us to discuss.

R4: The teacher comes with the phone and the laptop and uses it as a source of information for example if he is not sure about what is not in the text book to confirm if it's true or if it's false..

R6: The teacher prints something from the laptop and brings them to class during preps and tells us to do the questions.

The learners in school T indicated that their teacher used ICT integration to display videos and elicit a discussion, to refer to stored information and to assess the learners. On the day of visit, the researcher did not observe the teacher using ICT integration during the lesson.

In school R and S, the teachers used ICT in a similar way to display videos, to project questions with diagrams for learners to answer and also to project the notes.

The learners in school R said the following:

How do you and your teacher use ICT during the Biology lesson?

School R

R3: The teacher projects videos for us to see and asks us to discuss.

R5: our teacher also displays some questions with diagrams.

R1: She displays for us some notes but we also add more notes from other textbooks

On the days the researcher visited the school, the teachers in school S and R were both utilizing the computer, the projector and screen in their ICT integration. The

researcher observed the teacher in school R using ICT integration as follows:

Class observation: ICT integration: School R

The teacher used ICT to display Pictures of symptoms of diseases eg diarrheating, vomiting for class discussion.

The teacher played a video describing causes, symptoms and control of cholera

The teacher displayed notes and questions for learners.

The teacher referred learners to use their phones or parents' phones to get more information but this should be done once they closed school as they were not allowed to have phones in school.

The teacher was knowledgeable in using ICT. She did not seek the help of a technician. She also kept time

The researcher observed the teacher use ICT integration to engage the learner in class discussion through display of pictures, videos, questions and notes. The teacher also referred the learners to use ICT integration at home to get more information on the concepts learned.

In school U and V, the learners said nothing about ICT integration. On the days the researchers visited the schools, the researcher did not observe any ICT integration taking place. These findings about ICT integration in the schools that were studied agree with a study by Otieno (2022) who showed that ICT integration is minimal in most schools in Kenya. This finding is discouraging given the exposure ICT

integration may give learners more insight and help them have a better understanding of Biology.

From the qualitative study, the researcher established from the key informants how ICT integration influences achievement of learning outcomes. The key informant Y said the following:

KI Q: How does ICT Integration influence achievement of learning outcomes?KIY:

ICT integration can help learners visualize things so they will never forget. When learners see processes through simulations, they understand better. ICT integration makes teaching easier by allowing teachers to play more than one video allowing learners to compare and analyze knowledge.

Key informant Y reported that ICT integration may help learners achieve cognitive learning outcomes like remembering, understanding and analysis. These findings are in line with Ali et al (2021) who indicate that ICT integration may help learners remember and understand concepts better. From these findings, ICT use may promote fairly higher learning outcomes.

On the same concern of how ICT integration influences achievement of learning outcomes, key informant W said the following:

KI Q: How does ICT Integration influence achievement of learning outcomes? KIW

When there is ICT integration it amalgamates both low level and higher cognitive learning outcomes. For example, Simulation promotes cognitive outcomes such as understanding. When you use non digital technology, students may touch and observe and even experiment. This promotes skills learning outcomes such as observation and experimentation. ICT integration definitely promotes positive attitudes to learning Biology. The truth is that learners actually enjoy and we have seen cases where in a school only one teacher is using technology and the students wishing that they could be taught by that teacher who is using technology.

The key informant W informed that ICT integration promoted both low and high order cognitive learning outcomes. For instance, simulations may promote

understanding of concepts. ICT integration by use of non-digital devices may promote skills outcome such as observation and experimentation. The key informant W mentioned that ICT integration definitely promotes affective outcomes like helping students develop a positive attitude towards Biology. These findings about how ICT influences learning outcomes is in agreement with (Toh & Zaidatun (2024), who note that ICT integration is what can promote learning in today's world in not only enhancing achievement of both low and high order learning outcomes but also promoting interests of learners. These findings show that ICT integration can help learners achieve a range of learning outcomes and therefore ICT use should highly be supported by schools and the government.

From the qualitative study, the researcher established from the key informants why ICT integration was minimal in schools. The following is the responses from the key informants Y.

KIQ: why do teachers fail to integrate ICT in Biology teaching? KI Y

Some teachers just have phobia for ICT. Some schools are lacking connectivity. There is lack of power, internet and also the attitude of some teachers they just refuse to use ICT because they think it is a lot of work. Also lack of gadgets they can be expensive to afford.

Key informant Y listed challenges such as phobia for ICT, lack of electricity in some schools, lack of internet, poor attitude towards ICT integration and lack of gadgets due to high cost as the main challenges why teachers fail to integrate ICT in Biology teaching.

On the same note on why ICT integration was minimal in schools, key informant X said the following:

KIQ: why do teachers fail to integrate ICT in Biology teaching? KI X

We have 2 types of principals. Science based and art based. Anything to do with laboratory and such the science based understands. But now when it comes to ICT both these principals are the same; they think if teachers use computers and projectors they steal. If they are given a chance to use they will spoil. I was talking to one principal who has locked all the ICT gadgets in a certain school. I asked him 'don't you think they will get a virus?' so he asked me you mean computers can also get a virus? I said 'yes' he asked if a computer gets a virus and I go to the chemist which drug will I buy to kill those viruses? So that fear of unknown of stealing, getting spoilt etc is real. Some teachers can be funny though like in some schools where they were given the gadgets, ipads and locked up. Teachers were organizing with outsiders in breaking into the school and stealing them away because the head teacher was refusing to allow them. But it is sad some school principals cannot encourage you to have your own computer and prepare your schemes of work with it. They want hand written and yet there is technology.

The key informant X said that the main challenge hindering ICT integration is the principals' lack of understanding on the need to avail the gadgets to the teachers. Many principals thought that the teachers may steal or spoil the gadgets and so they keep them under lock and key. Some principals were even unaware that locking the gadgets may expose them to more harm for example the computer may get viruses. Due to this behavior of principals in some schools, the teachers were organizing with outsiders to steal the gadgets from school. These findings from the key informants on lack of use of ICT integration by teachers rhyme with the findings of Belay, Khatete & Mugo (2020) who revealed that most of the ICT resources required for teaching and learning were not available in schools, and those that were available were utilized to a very low extent. These findings call for awareness creation in schools to both the teachers and administrators on the usefulness of ICT integration in teaching and learning of Biology.

Convergent /Divergent Findings from the Quantitative/Qualitative Study on Use of ICT Integration in Biology Teaching

From both the quantitative and qualitative studies above, use of ICT integration in teaching of Biology is present. A lack of ICT use is largely due to the scarcity of such facilities and when available, not being utilized by older teachers. Both studies point to an improvement in learning outcomes with integration of ICT in biology teaching. This concurs with Rind et al (2022) who state that integration of ICT positively impacts academic achievement.

A divergence, however, is portrayed whereby many teachers are not aware that ICT use can be integrated in Biology teaching without the use of computers. While the quantitative study alluded to the availability of ICT equipment, the qualitative study also revealed that in some areas where ICT equipment had been provided, they were locked away by school principals and thus remained unused. This largely diverged from Masu & Abe (2025)'s study which directly linked inclusion of broadcast television and current affairs news channels in teaching to improved learning outcomes.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings, the conclusions and the recommendations of the study. The study investigated the teaching and learning of Biology and its influence on learning outcomes.

The objectives of the study were to:

- a) Assess the utilization of teaching and learning resources in Biology teaching and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- b) Evaluate the application of Biology curriculum in everyday life context and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- c) Assess the pedagogical techniques used in Biology teaching and its influence on the achievement of learning outcomes in public secondary schools in Nairobi County.
- d) Examine the integration of ICT in Biology teaching and its influence in the achievement of learning outcomes in public secondary schools in Nairobi County.

5.2 Summary of Findings

1. The number of male biology teachers who participated in the study was slightly more than the female gender, implying that the gender stereotype that science subjects like Biology are the preserve for men while women go for languages and humanities could be persisting.

2. Nearly half of the Biology teachers who participated in the study were aged between 25 and 34. This implies that many Biology teachers in Nairobi City County were youthful hence are favorable and may influence positively the participation of Biology learners.
3. Most of the teachers who participated in the study were Bachelor's degree holders and a few were Master's holders. These findings show that Biology teachers were well qualified, it was thus expected that they are able to teach the biology subject in accordance with the standards as per the curriculum guidelines.
4. Most of the teachers who participated in the study had teaching experience of more than five years. This finding suggests that most of the teachers had the necessary experience to positively influence learning outcomes of the Biology students
5. The key informants had an experience of more than 5 years hence would well give reliable information to the study.

5.2.1 Teaching and Learning Resources on the Achievement of Learning Outcomes

1. The study established that among material resources, all teachers and students utilized textbooks. Despite the textbooks being the main material resource used for reference and revision, some of the textbooks in use were reported to have errors and misleading information. This could mean that there was a risk of missing vital information from the relied textbooks.

2. In some schools, learners copied a text book into their note books because of inadequacy of textbooks. This must be time consuming leaving less time for students to comprehend the knowledge in the textbooks.
3. The study found out that textbooks promote low order learning outcomes such as recall. If the textbooks are well illustrated then they may promote understanding and application outcomes. This implies that the use of textbooks which was the most used resource in schools promoted low order learning outcomes.
4. Charts and graphs promote fairly high order cognitive learning outcomes such as comprehension learning outcomes while worksheets enhance higher skills such as application and analysis. In this study, charts and graphs were used to a lesser extent than textbooks meaning that high order learning outcomes such as application and analysis were rarely attained.
5. The study determined that all teachers acknowledged the importance of utilizing laboratories during the teaching of Biology. However, none of the schools observed utilized the laboratory for experiments. Learners were mainly taught from classrooms and even those who were taught from the laboratory, it was used just as room for learning with no experimentation on the day of visit. Learners further pointed out that use of laboratory was scarce. These findings imply that learning of Biology without experimentation most likely gave learners a limited outlook of Biology.
6. The study established that Biology teachers rarely referred learners to utilize the computer room, library nor TV room. For the schools that had libraries, the library was used by those learners that were interested for own use, computer room only for computer students and for those schools who possessed a TV room, it was for entertainment. This finding shows that use of varied

infrastructure in teaching and learning Biology was rare consequently leading to achievement of only those learning outcomes confined to the classroom.

7. The study found out that even though a good number of teachers did not utilize the library, the botanical garden, the aquarium and the zoo in teaching biology, the teachers appreciated that these facilities were useful in contributing to achievement of learning outcomes. This calls for provision of the named facilities and encouragement for teachers to utilize them.
8. The study found out that use of the laboratory can promote cognitive outcomes such as remembrance and application; skills outcomes such as observation, measurement and experimentation and affective such as increasing learners' interest. In this study laboratory use was minimal implying that learners may miss out on the learning outcomes that the laboratory enhances.
9. This study found out that use of both the library and the computer room can enhance cognitive outcomes such comprehension and analysis as well as increase the interest of learners to study Biology. Give that the library and computer room were not often utilized then there is likelihood that learners failed to achieve learning outcomes enhanced by the library and the computer room.
10. Use of the botanical garden, the aquarium and the zoo enhance higher cognitive outcomes such as analysis and synthesis; skills outcomes such as hypothesis creation and affective outcomes such as positive attitude towards learning Biology. Despite infrastructure like the botanical garden, aquarium and zoo enhancing achievement of high order learning outcomes, schools under study never utilized them meaning that the learners could only achieve low order learning outcomes especially from the classroom which was commonly used.

5.2.2 Application of Biology in Everyday Life on Achievement of Learning Outcomes

1. It came out from the study that nearly all teachers appreciated the use of observation, measurement, experiment and prediction science process skills in teaching biology. Teachers appreciated less the use of construction of models for learning and controlling of variables science process skills. These findings imply that use of higher/integrated science process skill was missing in action meaning that learners were likely to miss out on higher engagement for better learning of Biology.
2. It was established that younger teachers appreciated more the science process skills of setting up experiments repeatedly to obtain results in their classrooms than older teachers. This finding implies that learners taught by younger teachers are likely to benefit more on science process skills as younger teachers were enthusiastic to practice science process skills compared to older teachers
3. The study established that the curriculum guidelines have given room for learners to experience several science process skills such as observing, classifying, communicating, measuring, predicting, inferring, identifying and controlling variables, formulating and testing hypotheses, defining, interpreting data, experimenting and constructing models. However, there was admission that in the 8-4-4 system learners were not being taken through the science process skills and if they learn any, it is unintentional. This finding imply that learners are missing out on important science process skills which can help them a better understanding of Biology through everyday life.
4. The study found out that use of science process skills can enhance achievement of high order cognitive outcomes such as application, analysis and synthesis of

knowledge. Science process skills also enhance intended skill outcomes such as observation, measurement, manipulation of variable, and making inferences. In addition, use of science process skills helps in making biology interesting. Use of science process skills can help learners attain knowledge which they can use in life apart from passing examinations. It means that since it was found out that many learners were not exposed to science process skills then they missed out on achievement of high order learning outcomes enhanced by science process skills.

5. The study established that teachers appreciated the application of biology to everyday life using the nature of science to a great extent. The findings showed that male teachers appreciated more use of the aspect of the nature of science of ‘guide on clear distinction between theory and law’ more than the female teachers. This being the case, it may be assumed that male teachers may perform well in instilling some process skills such as manipulation of variables than female teachers.
6. It came out from the study that there was an attempt to use four out of eight aspects of the nature of science. The teachers mainly attempted the use one aspect of the nature of science which was “the clear distinction between theory and law” in which case the teachers pointed out to the really happenings in life. There were few instances of “Give room for socio- cultural knowledge to influence Biology knowledge” and one instance of Give opportunities for learners to associate Biology knowledge with social realities in the society. These findings show that use of the nature of science in teaching Biology was less meaning that learners missed out on instances that can help them have a better understanding and application of Biology.

7. The study established that in the ongoing 8-4-4 system, which is yet to be phased out, the application of Biology knowledge to everyday life through the Nature of Science (NoS) is lacking. In the so far newly curriculum guidelines of which the Secondary Biology designs are yet to be developed, there are tendencies of the nature of science though the intentionality is lacking. These findings imply that there is a likelihood of the NoS to be ignored in the CBC just like they were ignored in the 8-4-4.
8. The study established that through the use of NoS, such as by portraying the knowledge of biology as tentative, can help the learners to comprehend biology better and also be able to synthesize knowledge. By giving room for imagination and creativity it brings understanding of abstract concepts, by associating biology knowledge with the culture of the society, learners find biology interesting and hence develop positive attitudes towards it. When there is a separation of really happenings in learning from theories, the learners learn skills like making hypothesis and achieve learning evaluation cognitive outcomes. Connecting biology to social life helps learners attain analysis cognitive outcomes. These findings show that use of the nature of science may contribute to the highest order of learning outcomes such as evaluation and synthesis. Given that use of NoS was scarce then it was likely that many learners missed out on higher order leaning outcomes which could be enhanced by the use of the nature of science.

5.2.3 Pedagogical Techniques and Achievement of Learning Outcomes

1. The study established that teachers largely agree that collaboration, discovery, and problem-solving pedagogical techniques which promote active learning should be the key methods in teaching Biology. Explanation, open ended

question and demonstration techniques though passive may be used where necessary but should not take center. The teachers further appreciated that collaboration, discovery, explanation and problem-solving pedagogical techniques were very useful in achievement of learning outcomes. These findings imply that active pedagogy should be the center of learning Biology.

2. The study found out that younger teachers and teachers with less experience years appreciate more the project pedagogical technique. This finding indicates that there may be challenges that a teacher comes along with while in the teaching profession which pose a barrier to using active methods of teaching Biology.
3. The study established that the recommended Inquiry Lased learning, project-based learning and learner centered pedagogical techniques were missing in action. Instead, the passive methods of teaching dominated Biology teaching. This means that the learners could be missing out on the best methods of teaching that can help them grasp Biology better.
4. The study found out that active pedagogy enhances achievement of high order cognitive outcomes such as evaluation, analysis and synthesis; skills outcomes such as observation, experiment, hypothesis making; and affective outcomes such as positive attitudes towards learning Biology. This finding implies that learners missed out on high order learning outcomes which could be enhanced by active pedagogy.
5. The study established that passive methods promote student rote learning and memorization. With demonstrations and videos, the learners may achieve understanding outcomes and develop observation skills. For affective outcomes, passive pedagogy makes learners to get bored and consequently develop a

negative attitude to learning Biology. In this study passive pedagogy were the center of learning implying that the learners achieved low order learning outcomes, very basic skills and poor attitude towards Biology

5.2.4 Use of ICT Integration on the Achievement of Learning Outcomes

1. The study established that some of the ways ICT integration is applied through animations, simulations, for learners to engage; for the learners to explore and make conclusions or for assessment or making a presentation. But ICT integration in schools was minimal and in the few cases it was to display of pictures, videos, questions and notes for learners implying that even the ICT integration which was done did not provide for more engaging opportunities for better understanding and application of Biology.
2. It came out from the study that ICT integration promotes both low order and high order cognitive learning outcomes. For instance, ICT integration may help learners achieve remembering, understanding and analysis cognitive learning outcomes. ICT integration by use of non-digital devices may promote skills outcome such as observation and experimentation. ICT integration promotes affective outcomes of helping students develop a positive attitude towards Biology. This finding implies that ICT integration provides an opportunity for achievement of varied learning outcomes and yet in this study ICT integration was not common among schools.
3. It came out from the study that many teachers fail to use ICT integration due to lack of ICT gadgets; lack of knowhow; phobia to use ICT; time constraints while others just ignore using ICT. Additionally, lack of electricity in some schools, lack of internet, poor attitude towards ICT integration and principals' lack of

understanding on the need to avail the gadgets to the teachers. this implies that ICT integration was less often practiced denying learners a chance to understand Biology better.

5.3 Conclusions

The most used material resources by Biology teachers were textbooks followed by charts, graphs and then worksheets. According to blooms taxonomy, the order of cognitive outcomes is: remembering, understanding, applying, analysis, evaluating and synthesis. From the findings of this study use of text books enhances achievement of low order cognitive outcomes up to the understanding level. Use of charts and graphs enhances achievement of cognitive learning outcomes up to the application level while use of worksheets which was uncommon enhance up to applying level. This study therefore concludes that with the kind of material resources teachers and learners are utilizing they can only be able to achieve low order cognitive learning outcomes.

With infrastructure Utilization, schools mainly used the classroom and sometimes the laboratory for teaching and learning biology. The schools did not use the computer room, the library which enhance outcomes such analysis nor the botanical garden, aquarium and zoo which enhance high order learning outcomes. The infrastructure schools used therefore only enhance attainment of basic skills such as observation, measurement and a bit of experimentation but not high-level skills like hypothesis forming enhanced through use of infrastructure such as botanical garden, aquarium and zoo. Additionally, the infrastructure schools use will unlikely enhance positive affective learning outcomes as many learners don't find learning from the classroom interesting.

This study therefore concludes that utilization of teaching and learning resources in Biology teaching was inadequate and can only enhance achievement of low order cognitive, basic science process skills and negative affective learning outcomes.

In this study, application of Biology to everyday life by use of science process skills depicts a scenario where only basic science skills such as observation, measurement and experiment are being attempted. Learners were not experiencing any of the integrated (higher order) science process skills such as manipulating variables and construction of models. In as much as science process skills lead to a whole round achievement of all learning outcomes namely cognitive, skills, affective and enhance lifelong learning, this study concludes that with only the basic science process skills attempted, learners may only achieve low order cognitive learning outcomes and poor attitude towards Biology. It may be that that individuals who cannot use science process skills will have difficulty succeeding in daily life as science process skills enables individuals solve everyday problems.

Application of Biology to everyday life using the nature of science was not intentional in the curriculum guidelines. A few Biology teachers were trying on their own to apply biology to everyday life through some aspects of the nature of science but other aspects of the nature of science were lacking. Learning outcomes using the nature of science enhance achievement of high order learning outcomes ranging from cognitive, skills and affective such better comprehension and understanding of Biology; synthesis and evaluation. Skills like making hypothesis and achieve learning evaluation cognitive outcomes. Yet application of Biology to everyday life through the nature of science is minimal and consequently only low order cognitive, basic skills and lack of interest towards Biology may be achieved. This study

therefore concludes that application of Biology to everyday life was poor and hence low order cognitive outcomes, basic science process skills and lack of interest in Biology may be achieved.

Active pedagogical techniques which enhance achievement of high order cognitive outcomes such as analysis, evaluation and synthesis; skills outcomes such as observation, experiment, hypothesis making; and affective outcomes such as positive attitudes towards learning Biology were missing in action. On the other hand, passive methods which encourage rote learning and memorization giving a false impression that learning has taken place were dominant. This study therefore concludes that the use of pedagogical techniques in practice can only enhance achievement of low order learning outcomes such as memory and understanding. Consequently, low interest in Biology subject is expected.

While ICT integration help learners achieve cognitive learning outcomes such as remembering, understanding and analysis; affective outcomes such as developing a positive attitude towards Biology; ICT integration for simulations and animations enable achievement of learning outcomes up to the analysis level and enhance students' positive attitudes. ICT integration by use of non-digital devices may promote skills outcome such as observation and experimentation; Teachers rarely used ICT integration due to lack of knowhow; phobia; ignorance; and principals' lack of understanding on the need to avail the gadgets. This study therefore concludes that ICT integration was unsatisfactory and thus enhanced achievement of low order cognitive outcomes, inadequate skills outcomes and low interests in Biology.

5.3 Recommendations

Effective Biology teaching and learning for achievement of desirable learning outcomes requires that all implementers such as the MOE, KICD, CEMASTEА, universities, principals, Biology teachers and learners play their roles as expected of them.

5.3.1 Policy Recommendations

1. Text books being the most utilized Biology teaching and learning resource, KICD should put stringent guidelines on approval of textbooks for use as some of the books in use had errors and misleading information.
2. CEMASTEА, and the teacher training institutions such as universities should train teachers to use a variety of material and digital resources apart from text books as they enhance high order learning outcomes. Schools through principals should provide a wide range of material resources while teachers and learners should improvise other material resources.
3. The MOE working together with partners should provide and equip laboratories, libraries and computer rooms in schools. The MOE may also provide and manage a few zoos and aquariums at least one per county where a few schools can visit and learn Biology. Teachers and learners should use the facilities adequately for teaching and learning of Biology. In addition, every school is encouraged to provide a botanical garden for the teaching and learning of Biology.
4. The MOE working with partners should provide ICT gadgets and internet connectivity to all schools. KICD and CEMASTEА should organize awareness seminars for principals on the usefulness of ICT integration and INSETs for teachers on how to use digital resources and ICT integration.

5. Even though it was reported that the new curriculum guidelines contain some aspects of science process skills and the nature of science, KICD should see to it that the curriculum guidelines have intentionality in inclusion of the science process skills and the nature of science. KICD should further organize for INSETs for teachers and other curriculum implementers to be taken through interpretation and implementation of the science process skills, the nature of science and use of active pedagogical techniques.

5.3.2 Recommendations for Further Study

1. The findings of this study are limited in terms of the study locale and design. There is need therefore to conduct further research using either the same or a different design on the teaching and learning of Biology and its influence of learning outcomes in different parts of the country to get a clear picture and understanding of this subject.
2. This study was conducted in public secondary schools in Nairobi County. A similar study can be conducted in private schools to make comparisons and make suggestions of improvement in this subject.
3. A study on the role other Biology curriculum bodies in Biology teaching such as KICD, CEMASTEIA and Universities can be done to establish the influence of the various stakeholders on the process of Biology teaching and learning.

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APPENDICES

APPENDIX I

QUESTIONNAIRE FOR BIOLOGY TEACHERS

A STUDY ON BIOLOGY TEACHING AND LEARNING OUTCOMES,
NAIROBI, KENYA.

The purpose of this study is to investigate the teaching of Biology in the classroom and how it affects learning outcomes. This research is for the purpose of my academic study. As a participant, by contributing to this study, the recommendations that will be drawn may help in improving the teaching of Biology and the achievement of learning outcomes. All information you shall give and any happenings during the interview will be treated with utmost confidentiality.

Personal Information

Gender.....

Age.....

Highest Professional qualification.....

Years of experience in teaching Biology.....

Pertinent issues

Utilization of teaching and learning resources

In the following table, tick if you use and cross if you do not use the indicated resources, then in a scale of 1- 5 tick how useful you consider the indicated resources in achievement of learning outcomes. .

(5- Very useful 4-considerably useful 3- somewhat considerably useful 2- very limited useful 1- not useful at all). Please give reasons for your answers.

Resource	Tick if used cross if not used	Usefulness in achievement of learning outcomes				
		1	2	3		
Material resources						
Text books						
Charts						
Maps						
Graphs						
Others (specify)						
Infrastructure						
Laboratory						
TV room						
Computer room						
Library						
Others (specify)						

Application of Biology Content Knowledge to Everyday Life Context

In the following table, tick if you give students opportunities and cross if you do not give students opportunities in the following contexts in your everyday teaching, then in a scale of 1- 5 tick how the application of these contexts contribute in achievement of learning outcomes. (5- Greatly contributes, 4-considerably contributes 3- somewhat contributes 2- slightly contributes 1- does not contribute at all)

Context	Tick if applied cross if not	Contribution in achievement of learning outcomes				
		1	2	3		
Science Process Skills						
Observation skills (I give opportunities for students to use senses to identify changes and characteristics of Biological knowledge)						
Measurement skills (I give opportunities for learners to use measuring instruments to obtain more appropriate value)						
I give opportunities for learners to construct models for learning.						
Hypothesis making skills (I give opportunities for learners to propose explanations as a starting point for further investigation.)						
Experimental skills (I give opportunities for learners to set up experiments procedurally and repeatedly to obtain results)						
I give opportunities for learners to control and manipulate variables during experiments						
Prediction skills						

I give opportunities for learners to predict the outcome of experimental results						
Interpretation of data I give opportunities for learners to relate the observed characteristics and interpret the data						
Inference skills (I give opportunities for learners to make conclusions from the interpreted data)						
Communication skills (I give opportunities for learners to report findings from their investigations)						
Nature of Science						
I portray Biology Knowledge as tentative and not final/robust						
I give room for students to use more than one method of investigation						
I give room for creativity and imagination						
I guide on clear distinction between observations and inferences						
I guides on clear distinction between theory and law						
I identify and acknowledge names of scientists associated with the Biological discovery/knowledge						
I give room for socio-cultural knowledge to influence Biology knowledge						
I give opportunities for learners to associate Biology knowledge with social realities in society						

Pedagogical Techniques in Biology Teaching

In the following table, please tick if you agree and cross (x) if you do not agree with the statements regarding pedagogical techniques, then in a scale of 1- 5 please indicate by use of a tick your opinion on the extent to which the indicated statements on pedagogical techniques may contribute to achievement of learning outcomes. (5- Greatly contributes, 4-considerably contributes 3- somewhat contributes 2- slightly contributes 1- does not contribute at all)

Statement on Pedagogical technique	Tick if you agree and cross (x) if you do not	Contribution in achievement of learning outcomes				
		1	2	3		
Passive pedagogy						
Demonstration method Teachers should show students how an experiment works						
Explanation method Explanation of Biology facts and definitions provide the core of Biology teaching						
Lecture method Well prepared lectures are efficient and effective for most Biology topics						
Question/Answer method Biology teachers have in mind specific answers to questions they pose in class						
Active pedagogy						
Experimental / laboratory method Students carry out experiments on their own using apparatus provided						
Collaborative method						

Students work in groups, make written reports of the project and present their findings.						
Project method Students have an ongoing Biology project in my school						
Cooperative Method Biology students are provided class time for exchanging among themselves						
Inquiry method Sometimes in Biology teaching is used for students to explore material, ask questions and share ideas.						
Problem solving method Students identify and solve real problems during Biology classes.						
Discovery method Students are guided to find the truth about Biology for themselves by independent thinking						

ICT Integration and Biology Teaching

In the following table, please tick if you agree with the statement and cross if you do not, then in a scale of 1- 5 please indicate by use of a tick your opinion concerning the following statements on ICT integration's contribution in achievement of learning outcomes. (5- Greatly contributes, 4-considerably contributes 3- somewhat contributes 2- slightly contributes 1- does not contribute at all)

Statement on ICT integration	Tick if you agree and cross if you do not.	Contribution in achievement of learning outcomes				
		1	2	3		
Teachers encourage and allow learners to use digital tools such as computers, phones for further information/ research						
Teachers use ICT in class to show biological processes in the classrooms						
Teachers use ICT to project notes for students						
Teachers keep and retrieve information records using ICT.						
Teachers carry out assessment of learning with ease and speed using computer technology						
Teachers do not use ICT due to lack of facilities						
Teachers do not use ICT due to lack of training/know how						
Teachers do not use ICT due to time constraints						

APPENDIX II

INTERVIEW GUIDE FOR BIOLOGY SPECIALISTS

A STUDY ON BIOLOGY TEACHING AND LEARNING OUTCOMES,
NAIROBI KENYA.

The purpose of this study is to investigate the teaching of Biology in the classroom and how it affects learning outcomes. This research is for the purpose of my academic study. As a participant, by contributing to this study, the recommendations that will be drawn may help in improving the teaching of Biology and the achievement of learning outcomes. I seek your consent in recording the happenings of the interview for the purpose of this study only. In case you change your mind about participating, you are allowed to stop the interview.

All information you shall give and any happenings during the interview will be treated with utmost confidentiality.

Personal Information

Gender.....

Age.....

Qualification.....

Years of experience as a teacher.....

Pertinent issues

Utilization of Teaching and Learning Resources and Learning Outcomes

1. How should teachers utilize different types of teaching and learning resources in Biology teaching so that learners can attain high learning outcomes?
 - a) Infrastructure?
 - b) Material resources

Probe.

In your opinion, are teachers using the teaching and learning resources as they should? Why? Why not? How?

2. Please talk about the kind of learning outcomes that you think can be enhanced by Utilization of different types of learning resources, according to Bloom's taxonomy.

Application of Biology Content Knowledge into everyday life

3. a) How may teachers use application of Biology curriculum into everyday life in the teaching of Biology in secondary schools.
 - i. Science Process Skills (observation, measurement, hypothesis, experimental, communication)
 - ii. The Nature of Science (tentative and not final/robust, creativity and imagination, distinction between observations and inferences, distinction between theory and law, acknowledges names of scientists associated with the Biological discovery/knowledge, socio- cultural knowledge to influence Biology knowledge, associate Biology knowledge with social realities in the society)
 - iii. In your opinion, are the curriculum guidelines (syllabus, teacher's guide and Biology form three course book) applying Biology curriculum into everyday life in the Biology classrooms? Why? Why not? How? (KICD)
4. According to Bloom's taxonomy please indicate the kind of learning outcomes that can be enhanced by application of Biology content into everyday life?

Utilization of Pedagogical Techniques

5. Please describe which pedagogical techniques teachers should use during Biology teaching.
6. In your opinion, are teachers using the kind of methods of pedagogy you have suggested? Why? Why not? How?
7. How should teachers overcome the challenges encountered in the Utilization of active pedagogy such as project, discovery and inquiry methods?
8. According to Bloom's taxonomy please indicate the kind of learning outcomes that can be enhanced by use of active learning pedagogical techniques.

ICT Integration

9. Please describe the ICT integration techniques that you recommend teachers to use in Biology teaching.
10. In your opinion, are teachers using ICT integration techniques that you have suggested? Why? Why not? How?
11. Basing your response on Bloom's taxonomy, please indicate the kind of learning outcomes that can be enhanced by ICT integration.

APPENDIX III

FOCUSED GROUP DISCUSSION GUIDE FOR BIOLOGY LEARNERS

A STUDY ON BIOLOGY TEACHING AND LEARNING OUTCOMES,
NAIROBI KENYA.

The purpose of this study is to investigate the teaching of Biology in the classroom and how it affects learning outcomes. This research is for the purpose of my academic study. As a participant, by contributing to this study, the recommendations that will be drawn may help in improving the teaching of Biology and the achievement of learning outcomes. I seek your consent in recording the happenings of the interview for the purpose of this study only. In case you change your mind about participating during this interview, you are allowed to stop from participating. All information you shall give and any happenings during the interview will be treated with utmost confidentiality.

Personal Information

Gender: maleFemaleTotal.....

Type of school

Pertinent issues

Utilization of Teaching and Learning Resources and Learning Outcomes

1. In your everyday Biology lessons, how do you and your teacher utilize:
 - a) Infrastructure e.g. laboratories, classrooms, TV room etc?
 - b) Material resources e.g. text books, charts, maps etc? Probe.
2. In the study of Biology, you are expected to have achieved learning outcomes in knowledge, skills and attitudes of the subject by the time you complete form four.
 - i) Please state the kind of knowledge learning outcomes that can be enhanced by Utilization of different types of learning resources. (Remembering, understanding, applying, analyzing, evaluating, and creating)
 - a) Infrastructure e.g. laboratories, classrooms, TV room etc
 - b) Material resources e.g. text books, charts, maps etc

- ii) Please state the kind of skill learning outcomes that can be enhanced by Utilization of different types of learning resources? (Observation, experimentation, hypothesizing, inference)
 - a) Infrastructure e.g. laboratories, classrooms, TV room etc
 - b) Material resources e.g. text books, charts, maps etc

- iii) Please indicate the kind of attitudes/feelings (Biology is hard, easy, like, dislike etc) you may develop by Utilization of different types of learning resources? (observation, experimentation, hypothesizing, inference)
 - a) Infrastructure e.g. laboratories, classrooms, TV room etc
 - b) Material resources e.g. text books, charts, maps etc

Application of Biology Content Knowledge into everyday life

- 3. Do you think Biology is applicable to our everyday life? Discuss some of the instances referring to the syllabus which you have covered so far.
 - a) How does your teacher point out to these applications during the lesson?
 - b) How useful do you find the application of Biology subject to everyday life:
 - b) How do you find these applications helping you achieve the desired learning outcomes? (Knowledge, skills and attitudes)

Use of pedagogical techniques

- 4. Describe how your teacher **often** takes you through a Biology lesson from the beginning to the end of the lesson. (Probe for methods of teaching used).
 - a) Do you have a Biology project ongoing? Discuss (what is it about? How far are you with it? Do you think this can help you pass your examinations? Why? Why not? How?)
 - b) What kind of learning outcomes do you think project method of learning can promote? Knowledge (remembering, understanding, applying, analyzing, evaluating, and creating)
 - Skills (observation, experimentation, hypothesizing, inference)
 - Attitudes (like, dislike, hard, easy etc)

- 5. Do you have Biology class discussion groups? Probe. What kind of activities do you do and how do you run them? Do you do group activities during the Biology lesson or **only** during your own time?

What kind of learning outcomes do you think group discussions can promote?

Knowledge (remembering, understanding, applying, analyzing, evaluating, and creating)

Skills (observation, experimentation, hypothesizing, inference)

Attitudes (like, dislike, hard, easy etc)

6. a) What Biology problem have you solved in your class in the last one month?

Describe it?

- b) What kind of learning outcomes do you think problem solving can promote?

Knowledge (remembering, understanding, applying, analyzing, evaluating, and creating)

Skills (observation, experimentation, hypothesizing, inference)

Attitudes (like, dislike, hard, easy etc)

ICT Integration

7. How does your teacher use ICT (computer, phone, projector, radio etc) during Biology lessons? Probe

i) Simulation ii) retrieving information iii) keeping records

8. In your opinion, is your teacher knowledge in ICT integration in teaching Biology? Why? Why not?

9. What kind of learning outcomes do you think ICT integration can promote?

Knowledge (remembering, understanding, applying, analyzing, evaluating, and creating)

Skills (observation, experimentation, hypothesizing, inference)

Attitudes (like, dislike, hard, easy etc)

APPENDIX IV
OBSERVATION GUIDE

School Factors

- Type of School.....
- Gender of the school.....
- School Enrolment.....
- Class Enrolment (observation class).....
- Internet connectivity.....
- Number of Laboratories.....
- Number of computer Laboratories.....
- Number of TV Rooms.....
- Number of Libraries.....
- Number of School Halls.....

Teacher Characteristics

Teacher's Qualification:

- | | | | |
|---------|-----|--------|-----|
| Diploma | [] | Degree | [] |
| Masters | [] | PhD | [] |

Teachers' years of teaching experience.....

Teacher's in-service training:

- | | | | |
|------------------------|-----|-------------------------------------|-----|
| Not at all | [] | once | [] |
| more than once specify | [] | Syllabus coverage at par | [] |
| not at par | [] | if not at bar indicate the reasons. | [] |

Utilization of Teaching and Learning Resources: Describe a class discourse and observe the following:

Observation	Yes	No	Comment	Learning outcome exhibited as a result (knowledge, skills attitudes)
Physical Resources/infrastructure				
The learners were being taught from the regular classroom				
The learners were being taught from the laboratory				
The teacher referred learners to the laboratory for more practical work				
The teacher referred learners to the library for more information				
The teacher referred learners to the TV room for more information				
The teacher referred the learners to the computer lab for more information				
List other physical material/infrastructure observed or referred to during the lesson and how they were used.				
Material Teaching and Learning Resources	Yes	No	Comment	Learning outcome exhibited as a result (knowledge, skills attitudes)
The teacher used the text book during the teaching process				
The teacher referred the learners to the text books for more information				
The teacher referred the learners to the				

text books for exercises				
The teacher referred to the teacher's guide during the lesson				
The teacher referred to the syllabus during the planning of the lesson (check lesson plan)				
The teacher used charts to explain concepts				
The teacher used graphs during the lesson				
The teacher used maps during the lesson				
The teacher used real objects during the lesson				
List other material teaching resources used during the lesson and how they were used.				

Application of Biology curriculum into everyday life: Describe a class discourse and observe the following:

Observation	Yes	No	Comment	Learning outcome exhibited as a result (knowledge, skills attitudes)
<i>Science process skills</i>				
Teacher emphasizes on learners using senses to identify characteristics of organisms				
Teacher encourages learners to identify the instruments used during the experiment.				
Teacher asks learners to estimate quantities during measurement				
Teacher encourages learners to repeat experiments and measurements to obtain correct value of measurement.				
Teacher asks learners to set up instruments for experiments				
Teacher encourages learners to design their own experiments away from text books				
Teacher encourages learners to identify and observe precautionary measures when carrying out experiments				
Teacher encourages learners to express observations in appropriate quantitative description				
Teacher emphasizes learners to report events procedurally				
Teacher encourages learners to make				

assumptions based on observations				
Teacher asks learners to relate the initial assumptions and experimental results				
Teachers encourages learners to draw reasonable conclusions based on observation				
<i>The Nature of Science</i>				
Teacher encourages personal views and opinions to scientific facts				
Teacher emphasizes on not necessarily getting same results in standardized experiments				
Teacher emphasizes that knowledge scientific knowledge may change in future				
Teacher gives room for more than one method of investigation				
Teacher allows creativity and imagination during teaching				
Teacher guides on clear distinction between theory and law				
Teacher emphasizes on the person who initiated scientific discoveries				
Teacher asks learners to do experiments at home.				
Teacher allows for socio- cultural knowledge to influence Biology knowledge				
Teacher gives opportunities for learners to associate Biology knowledge with social realities in the society				

Pedagogical Instructional practices: Describe a class discourse and observe the following:

Observation	Yes	No	Comment	Learning outcome exhibited as a result (knowledge, skills attitudes)
Teacher uses pictorial and graphical illustrations to facilitate easy reflection by learners.				
Teacher addresses respective objectives as in the syllabus during teaching.				
Teacher asks questions not directly answerable from textbooks.				
Teacher encourages guessing and hypothesizing.				
Teacher refrains from judging students' behavior or work.				
Talk and activity are initiated and maintained by students.				
Teacher asks questions or invites comments which are answered by recalling facts and principles.				
Biology facts and definitions provide the core of Biology lesson.				
Students have a Biology project on going				
Students are given work in groups and given time to do it during the lesson				
Demonstrations dominate activities in the class/laboratory.				
Other pedagogical practices observed				






ICT Integration: Describe a class discourse and observe the following:

Observation	Yes	No	Comment	Learning outcome exhibited as a result (knowledge, skills attitudes)
Teachers use ICT in class to bring events from far distance in time and space into the classroom for lesson discussion				
Teachers keep and retrieve information records using ICT.				
Teachers carry out assessment of learning with ease and speed using ICT				
Teachers refer learners to use digital tools such as computers, phones for further information/ research				
Teachers refer learners to use digital tools such as computers, phones for further information/ research				
Teachers are knowledgeable in using ICT appropriately during the lesson				
Teachers engage services of a technician in using ICT in during the lesson				
Teachers attempt to integrate ICT during the lesson but lack appropriate gadgets.				
Teachers attempt to integrate ICT during the lesson but lack enough time.				
Teachers attempt to integrate ICT during the lesson but lack the know-how.				
Other ICT integration practices observed				

Additional notes from clarifications during lesson observation.....

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APPENDIX V
RESEARCH PERMIT

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