DISTRIBUTION OF EXAMINATION QUESTIONS ALONG BLOOM'S COGNITIVE DOMAIN; AN ANALYSIS OF KCSE BIOLOGY EXAMINATION IN KENYA: 2008-2018

BY

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A RESEARCH THESIS SUBMITTED TO THE SCHOOL OF EDUCATION, DEPARTMENT OF DEPARTMENT OF CURRICULUM INSTRUCTION AND EDUCATIONAL MEDIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF EDUCATION IN EDUCATIONAL COMMUNICATION AND TECHNOLOGY

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DECLARATION

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I dedicate my work to my family for their love and unwavering support throughout my master’s studies. May this work be a source of inspiration to you all.

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ABSTRACT

Every year, The Kenya National Examination Council (KNEC) administer examinations as a test mechanism to gauge student's understanding and their ability on topical aspects learned. The purpose of this study was to analyze in details the quality of exams administered to students. A balanced examination test should cover all levels of learning as summarized by Bloom in his famous Bloom's taxonomy which outlines the levels of learning as Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Thus, the main objective was to identity the level to which Kenya National Examination Council examines key areas of learning in biology in accordance to Blooms' Cognitive domain and if the examination meet's the objective of teaching biology in secondary school in assessing all the cognitive domain. The study adopted mixed method approach. Document analysis was employed in data collection. The study analyzed the past KCSE biology examinations dating 2008-2018. Bloom taxonomy was used as the guiding principles in analyzing the biology question items to the various levels of the cognitive domain. The criteria in each question was interpreted based on action verbs prescribed in Blooms Taxonomy and assigned to the relevant level in the domain**.** The data sheet was used to capture and tabulate the cognitive levels of the questions from KCSE examination papers. Information collected was interpreted via scientific process of coding and systemic variation. The data collected was edited, coded and classified on the basis of similarity with the themes and then tabulated. The analyzed data was presented in form of tables and graphs. The finding's revealed that KCSE examination conducted by KNEC are not as adequately demanding tasks, as they should be, most dominant questions are lower-order cognitive question; knowledge, comprehension and application with 87.25% frequency and 84.49% mark allocation while analysis, synthesis, and evaluation had lower frequencies of 12.75% and mark allocation of 15.51%.Higher-order questions was not effectively implemented, thus examination did not adequately meet the objectives of learning biology education in secondary schools. The research recommends that, Higher order cognitive skills of analyzing, synthesizing and evaluating that fosters orientation, concept strategies and assessment methodologies should be embraced by examination body as teaching focus in schools. This result is important, as it will help improve educational practices and programs by all the stakeholders in the process of testing; curriculum developers and examination designers will know the crucial nature of testing that measures all the levels of cognitive abilities. People whose main interest may be in assessment will have a check list on probably how to make a better test.

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ABBREVIATION AND ACRONYMS

BSCS	Biological Sciences Curriculum Study
HOCS	High Order Cognitive Skill
KCSE	Kenya Certificate of Secondary Education
KICD	Kenya Institute of Curriculum Development
KNEC	Kenya National Examinations Council
LOCS	Lower Order Cognitive Skill
NACOSTI	National Commission for Science, Technology and Innovation
SDG	Sustainable Development Goals
SMASSE	Strengthening of Mathematics and Science in Secondary Education
SPSTA	Science process skills teaching approach
UNESCO	United Nations Educational, Scientific and Cultural Organization

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Introduction

This chapter will look at the Background of the study, statement of the problem, purpose of the study, the study objectives, research question, significance of the study, assumptions of the study, the scope of the study, limitation of the study, theoretical and conceptual framework, operational definition of terms and the chapter summary.

1.2 Background of the Study

Science is a field concerned with the study of natural phenomenon through systematic observation and experimentation, school science is crucial in laying the foundation for scientific and technological development in society (Ozgelen, 2012), it helps individuals grow innovatively and critically and attain relevant competencies for sustainable advancement and its central to economic prosperity and to reaching the overall realization of Sustainable Development Goals (Yenice& Aktamis, 2010; Christou & Pitta-Pantazi, 2013).

Sustainable Development Goals (SDG) presents huge opportunities through a strategic shift towards equitable quality education for all, not just in terms of what students can remember and recall, but what students are able to do with their knowledge in their individual life and the society at large. According to Education 2030 of the year 2016, Quality education fosters creativity and knowledge, it ensures the acquisition of foundational skills of literacy and numeracy as well as analytical, problem-solving, metacognition, innovation and other high-level cognitive, interpersonal and social skills. This shift is essential in order to meet the current changes in the world where only the people who possess knowledge and skills, and are able to apply the knowledge in new situations, can realize an effective change (Gillies et al., 2014).

Science has led to rapid innovation all over the world. Cognitive and higher order thinking are the new pathways for sustainable development. Higher order cognitive skills in science education deals with analytical, critical thinking and problem solving which is often manifested by asking question and in making decisions (Burton et al., 2012). According to Hurd (1961) higher order thinking will shape Biological sciences for a globally competitive world. It will inject the aspects of advanced reasoning and cognitive aspects to the center stage in education. In his suggestions, Hurd (1961) was particular about Biological sciences in which he hinted that: There is need to entrench more reasoning more than memorization in education, the need to apply learning into real life scenario and the importance of having a system that is model driven and problem solving among learners.

Students' assessment is one factor that can be used to guarantee the quality of education (OECD, 2013). Lecturing and studying requires specific evaluation in order to gauge the student's performance. It is a critical step in the learning process, it determines whether or not the course's learning objectives have been met (Olorundare, 2014). This is an evolving and critical process in the teaching fraternity. Evaluation is a wholesome undertaking that encompasses the key tenets of quality, effectiveness and efficiency to achieve set parameters (Kellaghan et al, 2001). Learning mandates suggest clear strategies in which students ought to be empowered and transformed in their reasoning through an innovative learning culture. Bloom (1956, p. 26) further highlights that, examination test the extent to which the students have attained these educational objectives.

Anderson and Krathwol (2001) asserts that, taxonomy table is useful in education as it helps educators align objectives, instructional activities and assessment. Teachers and curriculum makers use taxonomy table model for the analysis of educational outcomes in the cognitive area of remembering, thinking, and problem solving (Anderson & Krathwol, 2013). Taxonomy table is also used to specify objectives so that it becomes easier to plan learning experiences and prepare evaluation devices. Whenever evaluation is not properly matched with the learning objectives, it will not lead to a clear goal of the learning objective. It is therefore imperative for the curriculum developers to ensure that there is a strong correlation between the curriculum and assessment (Amua-Sekyi, 2016).

Assessment task used to determine learning outcomes or measure learner's competency should be activities that are authentic, important and actual skills that will steer students in the realization of their dreams (Lamprianou & Athanasou, 2009). That is, examination given to students should give an indication of the degree to which pupils have attained the objectives of the course: attitudes, appreciations, skills in thinking and learning and the depth of interest to think scientifically. It should provide evidence of the student's ability to apply learned elements in new situations and to draw valid conclusions from a given set of data (Dunn & Mulvenon, 2009).

Examination that test on simple acquisition of knowledge are important only, when the facts are essential to the attainment of more important objectives of instruction (Bloom, 1956). Bloom proposed for student to be sharpened on the application of knowledge along the higher order thinking skills, as this contributes to creativeness of students and their criticism ability. This is an efficient approach for strengthening fundamental lifelong conceptualization and improving the quality of education (Amua-Sekyi, 2016). Teachers who set higher order cognitive skill question foster interaction between themselves and their students (Brualdi, 1998). Cognitive levels are arranged in order, from simple to complex. Cepni (2003) states that students might be at different cognitive levels. Therefore, questions should tap students' higher-order cognitive skills (HOCS) such as their ability to select and apply conceptual knowledge in new situations or solve real-life problems (Zoller & Pushkin, 2007). To make it effective, balancing between lower and higher-level question is a must (Swart, 2010).

The Kenya National Examinations Council usually carries out an empirical evaluation of work in progress, placed at the end of a course or program to determine the level of students' achievement or how well a program has performed. This summative assessment often takes the form of external examinations which tests learners for the final results in order for them to progress to tertiary level. Unfortunately, most of the assessments have resulted in sharp criticism from where experts have alluded that the Kenyan system is exam oriented as opposed to critically examining candidates basing on critical thinking. For instance, the Taskforce report (2012) and the Sessional Paper No.2 of 2015, has laid more clarion on examination-geared authentication by the end of every process (KICD, 2016). This has killed innovation that has led to churning of graduates without the necessary skills to cope with global competitiveness.

Apollo Research Institute (2012) documented the significance for skills gained through auxiliary components of instruction, spotting that schools were not geared to produce graduates for the 21st century workforce, not because they were incapable but due to competing demand by stakeholders in education. This perhaps serves to exemplify the education environment in Kenya. Githui et al. (2018) states that secondary schools are under pressure from stakeholders across the board to produce learners with high test scores as opposed to practical problem solvers. There is also the overwhelming emphasis for learners to pass national examinations and secure the limited positions in public universities. This overemphasis on theoretical education relegates important life skills such as creativity and critical thinking in the background and predisposes learners to compete for limited openings in the job market. Such an education system only serves to create job seekers in formal employment as opposed to “creators” of employment. Undoubtedly, learners are prepared to enter the existing workforce upon completion of schooling with little innovative entitlement in their credentials. A gap in innovation is apparent in relation to skills of thinking creatively, particularly in terms of self-employment (Githui et al.,2018). Creative thinking is one of the most sought educational outcomes in the 21st century as a response to the demand for innovations and technological advancement in addressing challenges of the global economy. The world conference on education for all (EFA, 1990) in Jomtien, Thailand and the international community underscored the importance of world nations to develop a relevant education that focuses on equipping learners with appropriate life skills (UNESCO, 2012). The demand for a work force endowed with creative thinking abilities has led educational policy makers around the world to align their educational goals and curricula in ways that foster development of creative thinking abilities among learners in schools.

Added to this, is a rapidly changing and unpredictable world that is almost impossible to foresee the particular problems to be faced in the near future like the new Covid 19 pandemic. Under these conditions, individuals should be prepared for unforeseen problems by putting emphasis in schools on the development of generalized ways of attacking problems and on knowledge which can be applied to a wide range of new situations. Teachers and curriculum developers should also find ways of helping students attain generalized reasoning capacities and added abilities that will navigate them in different perspectives. Bloom (1956) indicate that intellectual abilities and skills (Comprehension, application, analysis, synthesis and evaluation) refers to situations in which one is expected to bring specific technical information to bear on a new problem (Clark, 2010; Yahya et al., 2012). These intellectual abilities are more widely applicable than knowledge, Blooms' taxonomy is therefore useful in helping determine the level of specificity at which statements of objectives can be utilized in planning learning experiences and suggesting types of evaluation evidence which might be appropriate (Kellaghan et al, 2001). Thus, one approach of how to properly benchmark the evaluation tactics, is by application of Bloom's cognitive approaches. According to Bloom (1956), such assessments employ more cognitively demanding tasks which require students to demonstrate application, analysis, synthesis, evaluation and not merely, tests on memory (that require demonstration of knowledge and comprehension).

Proper application of Bloom taxonomy in examination is therefore very essential in determining the extent to which holistic learning has taken place (Forehand, 2010). It acts as a guide to ask and write better questions and assist the students in development of their meta cognitive skills. It provides a means to consistently apply the principles of Bloom's to biology concepts and skills, allowing us to better assess student-learning outcomes (Kellaghan et al, 2001). The concern of this study was therefore to determine whether summative examination in Kenya Secondary Education measures all the cognitive domains based on Blooms Taxonomy in accordance to secondary school Biology goals, aims and objective. It is also critical to note that this study will be of relevance as it will guide examiners in setting examination questions in line with the Country's needs. This research will provide a platform where students are examined qualitatively. By this, Blooms' taxonomy will be adopted as chain link between the effectiveness of examination and the quality of education in the Country. Quality education implies that the country will have a just social and sustainable order. Categorically, my study dealt on Biology because it is the backbone of biological sciences and in careers in industries that include biotechnology, food industry, chemical and pharmaceutical. Biology is equally an important subject on both agriculture, aquatic and environmental science as well as wildlife. It's the backbone of our country's economic competitiveness.

1.3 Statement of the Problem

The purpose of education is to develop knowledge, skills, and attitudes. Education system is however adjusting to meet global demands by emphasizing the need to achieve higher level of thinking, this is due to rapid changes in information technology globally.

Kenya's 'National Education Sector Plan' (2015) report, indicated that Education attainment at the secondary school level is low. The committee of experts on Realignment of Education to Kenya's 2010 constitution outlined a number of pitfalls to the 8-4-4 education system; that it has limited emphasis on skills development but rather provides an easy pathway to exam passage. The committees' proposal was to have an education system that is anchored on the needs assessment and the overall goal of promoting economic growth.

The 'Basic Education Curriculum Framework' (2017) further asserts that, education in Kenya is criticized for encouraging rote learning, rather than critical, creative thinking and problem solving. Textbook knowledge, rigid ideas and test scores take precedence over logical reasoning. Textbook knowledge as an outcome of education, does not create the kind of citizens needed to cope with social, economic and technological changes in the world (Klemm, 2007).

This study therefore, seeks to point out how education and its competitiveness has influence in our Kenyan society in coping with emerging global trends. It attempts to ascertain the cognitive level's tested in biology question items with a view of determining the quality of education sector in Kenya. The research will examine the several arrays through which knowledge can be attained at different levels as explained by Bloom in Bloom's taxonomy. If the questions are included in higher order cognitive levels, they are bound to produce creative individuals, critical thinkers and problem solvers, who then will be bound to contribute more meaningful to their individual well-being and to the country's national development.

1.4 Purpose of the Study

The primary objective of this study was to analyse in detail the quality of KCSE Biology examination administered to students if it meets development of higher cognitive skills.

1.5 Research Objectives

The following specific objectives guided the study

i) To analyse the KCSE (2008-2018) Biology questions in light of Bloom's cognitive domain.

ii) To determine the extent to which KCSE Biology questions seek development of higher order cognitive skills.

1.6 Research Questions

The study sought answers to the following research questions.

i) What kind of cognitive levels do KCSE Biology questions items measure based on Bloom taxonomy?

ii) To what extent do KCSE Biology questions seek development of higher cognitive skills?

1.7 Justification for the Study

According to KICD (2016) assessing learning outcomes has become a great concern among stakeholders. Numerous KCSE and University graduates entering the market do not meet consumer expectations. The mismatch in training curriculum and labor market is far apart. This has largely been blamed on the content and quality of our 8-4-4 education system. There has been a lot of emphasis on certification at the expense of learning. This is according to the evaluation carried out by the Kenya Institute of Education in 2009. Although Ministry of Education in Kenya lays a lot of emphasis on assessment, there is a lot of pressure on those in charge of curriculum implementation to perform highly in national exams. This sensation has often pushed teachers to focus more on exam coaching and drilling rather than the broader objective of holistic education (KICD, 2016).

It is against this backdrop that the study sought to investigate how the KCSE Biology questions in the examination items are structured along Bloom's cognitive domain. Questions should be distributed along all the various cognitive levels. According to Brookhart (2010), essential qualities of a 21st Century Learner entail: asking questions, thinking strategically, communicating effectively, using metacognition, problem-solving, making inference, logical reasoning, creators, and innovators. This in essence is in tandem with the higher level of cognitive thinking that promotes skills development for progressive growth an issue deeply engrained in this study.

1.8 Scope, Delimitation and Limitations of the Study

1.8.1 Scope and Delimitation of the Study

The study was based on past KCSE Biology examinations from 2008 to 2018. The research analyzed KCSE Biology questions. Other subjects were not included in the study. The study emphasized on qualitative techniques in assembling its information and quantitative approach in presentation of the data.

1.8.2 Limitation of the Study

This section identified the difficulties that was experienced during the study. Testing in Biology may not be the same as testing in other subjects, hence a probable limitation in application of the results obtained. As outlined by Bloom et al. (1956), the task of classifying examination is more complicated than classifying educational objectives because before the reader can classify a particular test exercise, the researcher must know, or at least make some assumptions about the learning situations which preceded the test; the researcher must also attempt to solve the test problem and note the mental processes utilized which might be different to what the student used; consideration should also be taken of the possibility of the processes used in selecting the correct answer.

According to (Anderson & Krathwol, 2009) When one applies a classification system to evaluate the work done, some complexities and problems are encountered, like the outcome desire a connections of purpose, which are cumbersome when objectives lack important words, verbs or phrases or are misleading or do not mean what they seem to mean.

1.9 Assumptions of the Study

This study was undertaken with some assumptions. It assumed that;

i. That the researcher's categorization of the questions into the various levels were correct.
ii. That the information collected was truthful and accurate to the various questions in the research instrument
iii. It is also assumed that the lower-order Cognitive domain was included in the higher categories. For example, it is assumed that the examination questions classified into the category Analyze required also cognitive processes Knowledge, comprehension and application.

1.10 Theoretical Framework and Conceptual Framework

1.10.1 Theoretical Framework

The research capitalized its research on Bloom’s Taxonomy on Cognitive domain of learning. Bloom advanced the fact that Cognitive learning can be categorized into several levels depending on the level of functionality, resulting from the learning. He categorized the cognitive levels into six levels: knowledge, comprehension, application, analyzing, synthesis and evaluation (Forehand, 2005). Bloom’s theory opined that examinations must test the key aspects of cognitive skills. Adams (2015) summarized the six levels of Bloom’s taxonomy as: Knowledge level which is based on restoring important knowledge, it’s the refreshing of information, it entails foundational cognitive skill that require students to retain learned information. In this level it’s important to check how well a student learned new information: specific facts, dates, and terms. Comprehension deals with the understanding of realities, data as well as interpreting; learners explain the content of knowledge learned in their own words. The test in the comprehension level helps check if the learner can go beyond basic recall and has understood the meaning and correlation of the key concepts. verbs like explain, find, define, compare. Application level refers to exercising skills gained to ascertain its practicality in real life, it deals with students using knowledge in new situation. Application level help test the learner's ability to put the acquired knowledge into action. The questions include verbs like apply decide, calculate and use. Analyze domain includes a thorough overview of information to provide a basis for action and or undertaking, learners in this level distinguish between facts and opinion and the questions include verbs like compare, contrast, highlight and distinguish. Synthesis refers to the ability to put parts together to form a new whole, it entails deep process of putting outcomes into perspective for purposes of realizing results. Evaluation is concerned with the ability to judge the value of a statement for a given purpose, students critically appraise the validity of a study and judge the relevance of the results for application. Evaluation level checks if the learner can come up with a new solution based on new information, evaluate the situation, and act independently. Questions verbs in the domain include: conclude, prove, justify, judge, check, evaluate, and recommend.

Sample questions of each Blooms cognitive domain include:

Knowledge: Name the taxonomic grouping that contains individuals with most similarities. Comprehension: Explain the role of blood capillaries in thermoregulation. Application: Calculate the magnification of the diagram. Analysis: Distinguish between chemical and mechanical digestion. Synthesis: Construct the dichotomous key of the following organisms. Evaluation: Justify how farming practices favor asexual reproduction and heterozygoty.

The Bloom's Taxonomy of Benjamin Bloom (1956) was therefore used focusing on all the cognitive levels: knowledge, comprehension, application, analysis, synthesis and evaluation, where the first three levels measure the lower thinking level while the other three assess the higher-level thinking. These are the dimensions that informed this study.

1.10.2 Conceptual Framework

The conceptual framework of this study was based on the level of cognitive domain in the KCSE Biology examination questions. The framework is important as it will serve as a checklist in setting Biology examination. The relationship between components of the research is as shown in fiqure1.1 below.

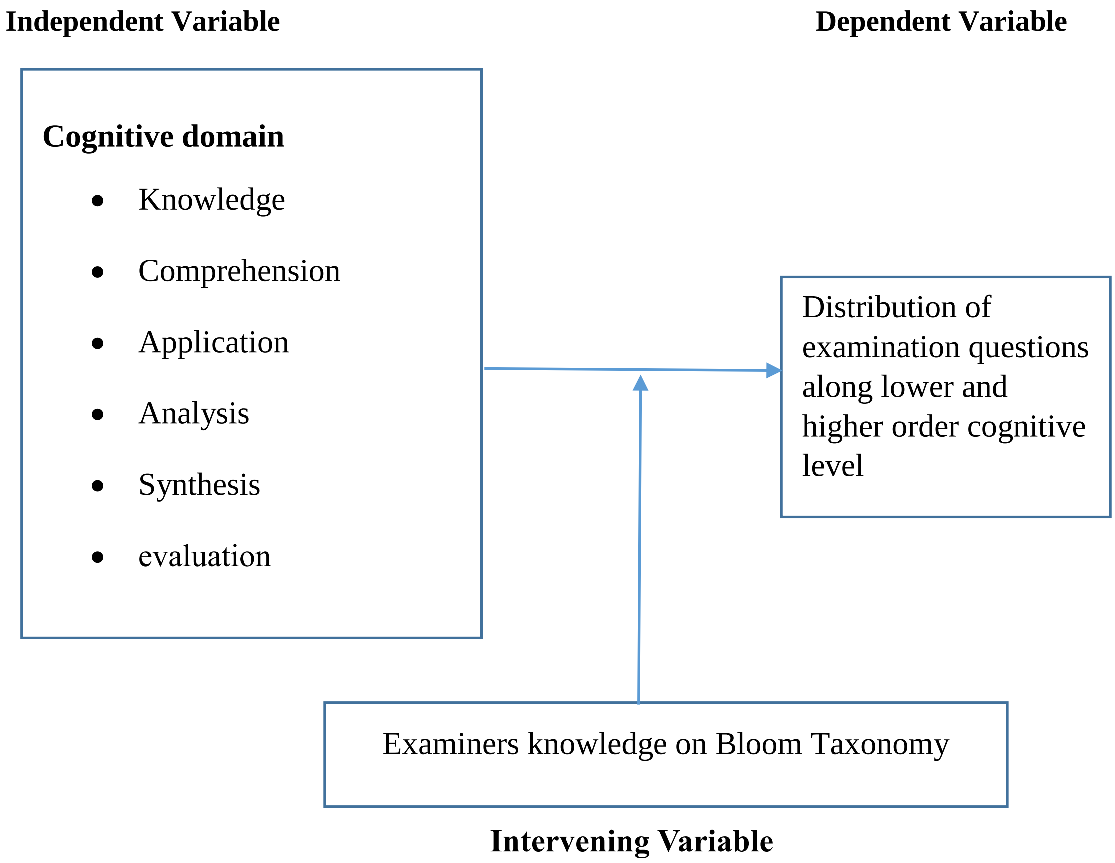

Figure 1.1: Conceptual framework

Figure 1.1 shows how the conceptual framework was operationalized. It indicates that Distribution of examination questions is dependent on the various levels of cognitive skills. If the questions test on knowledge, comprehension and application level it means the question are going to be distributed along lower order cognitive domain. However, if the questions are in synthesis, analysis and evaluation domain, the examination will be distributed along higher order cognitive domain. Examiners knowledge on bloom taxonomy is an important key function that contribute to the type of questions set by examiners.

1.11 Operational Definition of Terms

Assessment: This entails standardized test used to evaluate a variety of cognitive processes such as knowledge, problem-solving and reasoning. Involve setting of education objectives, placing standards, monitoring and evaluating with a view of enhancing quality. Focuses on how many of the education goals and objective have been achieved and provides a feedback on how educators and curriculum developers can enhance teaching and learning process.

Biology: Learning curriculum that is a branch of science dealing with the study of life and living organisms.

Bloom's taxonomy: is a classification system of educational objectives and assessment based on the level of student understanding necessary for achievement, or mastery of knowledge. The defined terms are organized from simple to complex and from concrete to abstract.

Cognitive Domain: refers to learning outcomes related to memory, understanding, and reasoning. It entails the creation of our mental skills and the attainment of knowledge. The main sub group of this domain include: knowledge, comprehension, application, analysis, synthesis and Evaluation.

KCSE Examination: Test given to assess the acquired knowledge, after learning and teaching processes at the end of Secondary education.

Kenya National Examination Council: A body empowered in Kenya to set, mark National examinations and give certificates.

Evaluation: is the process of collecting data on the students' learning. It's an efficient way to scrutinize ones' educational advancement especially the understanding of knowledge. Involve the process of judging the quality, importance and value of an assessment.

Learning objectives are brief statements that describe what students will be expected to learn by the end of the school year and course unit.

Levels of Cognition: The six levels (Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation) of Bloom's Taxonomy utilized to classify cognitive processes elicited by questioning strategies and/or verbal behavior.

1.12 Chapter Summary

This chapter has provided rationale for conducting the study and this can be seen in the introduction, background to the study, statement of the problem, aim and objectives, research question, assumptions, significance, scope and delimitation of the study, limitation, assumptions, conceptual and theoretical framework and definition of operational terms. It is clear that Bloom's Taxonomy is a proper benchmark to assess learning and teaching activities with the cognitive learning domain and the primary goal of teachers and examiners with the taxonomy of Bloom is to help learners think more by building the cognitive skills both at lower and higher levels.

It is worth noting that the Kenya National Examination Council has the solemn duty of assessing learners in a manner that is coherent and promotes the cognitive level of thinking. Through this study, the research recommends to the Kenya National Examination Council on the most efficient methods that will ensure that our testing promotes the Cognitive level of higher thinking. The study will place primary focus on the need to develop assessment practices that facilitate realization of meaningful outcomes of learning Biological Science. The study further endeavors to provide recommendations that will help shape and improve the quality of education in line with our vision 2030 and Sustainable development goals, that will lead to the attainment of competencies in Biology education. Competency-based learning is the call of the time in the Kenyan education system. This study is therefore timely.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviewed literature that pertains to the following research objectives; To analyse the KCSE Biology questions (2008-2018) in light of Bloom's cognitive domain. To determine the extent to which KCSE Biology questions seek development of higher order cognitive skills. Related research studies and the summary of the chapter was given.

2.2 To Analyse the KCSE Biology Questions (2008-2018) in Light of Bloom's Cognitive Domain

This section discussed the literature on; assessment, History of Biology, overview of Biological knowledge, introduction of Biological science into the school curriculum, application of biological knowledge in the society, the objectives of learning Biology in Secondary Schools, Bloom Taxonomy and its characteristic, assessment, Blooms knowledge and thinking skills in learning Biology.

2.2.1 Assessment

Assessment refers to a series of measurement used to gather and interpret information about student attainment of education goal. Tests and questions provide relevant measures of important learning outcomes (Dunn & Mulvenon, 2009). It entails not only what learners know but what they can do with what they have learn; it involves knowledge, abilities, values and attitudes that affect both academic success and performance. Assessment should therefore reflect these understandings by employing a diverse array of methods for a more complete and accurate picture of learning Assaly & Smadi, 2015.

Assessment aims to provide the information of students' performance in order to help the stakeholders to determine a certain degree, to which a learner has acquired particular knowledge, has understood particular concepts or has mastered certain skill. It determines student strength and weakness so that educators can provide academic support educational program. It provides feedback on effectiveness of instruction (Lamprianou & Athanasou, 2009).

Final assessment takes place at the end of a learning course and is used for summative decision-making and requires that, it should cover different cognitive domain of Bloom taxonomy for it to cover different capabilities and abilities of learners (Jones,Harland, Reid & Bartlett, 2009).

Bloom's Taxonomy further, provides an excellent structure for planning, designing, assessing and evaluating teaching and learning process. The model serves as a checklist, by which one ensure that instruction is planned to deliver all the necessary development for students. Assessment strategies that focus on recall of knowledge promotes superficial learning. On the other hand, assessment strategies that demand critical thinking or creative problem solving, are likely to realize a higher level of student performance. In addition, assessment with all the levels of cognitive domain help students become self-directed learners (DarlingHammond 2006). Well-designed assessment strategies play a critical role in educational decision-making and are a vital component of ongoing quality improvement processes at the curriculum level.

Examination questions should be designed in a way that help students, form creative answers, and relate the exam answers with their own experiences and real-life situations (Assaly & Smadi, 2015; Sydoruk, 2018). This study therefore, seeks to examine the degree to which KCSE Biology questions prepared by the Kenya National Examination

Council include both higher and lower-order thinking levels. The study assess how well students master the information within the six levels of the taxonomy and it further, analyze whether the exam questions are based on both higher and lower-order thinking levels.

2.2.2 History of Biology

The early history of biological knowledge was derived from traditions and medicine. Assyrians and Babylonians cultivated plants, (silkworm) Bombyx mori was used by China to produce silk: both understood the principal of biological control, Greek philosophers around 600 BCE contributed on the idea of rational thought, by believing that each event has a cause and effect. This had a profound impact on further scientific research. From 3rd to 11th century, biological knowledge dominated in Arab countries, Aristotle's work (on animal classification, reproduction, and heredity) and Galen's works were discovered, these led to translation, printing and further development in the Middle Ages. Botany emerged from the study of plants in the 12th century, while zoology emerged from veterinary medicine and hunting (History of Biology, 2019).

According to History of Biology (2019) in the period of Renaissance between 14th century to 17th century, there was rebirth of learning and books about plants were published. Seventeenth-century Advances in biology included the formation of scientific societies for the dissemination of ideas, as well as progress in the development of the microscope which laid the groundwork for Schleiden and Schwann's cell theory, these had far-reaching implications in biology. The importance of comparative study of living organisms, including humans, was discovered in the 17th and 18th centuries. The cell theory, embryology and paleontology laid the foundation of evolution in Charles Darwin theory of Natural selection. The discovery of the double helical structure of

DNA in 1953 marked the transition to the era of molecular genetics, which led to emergence of new disciplines.

Biological research was therefore, primarily a professional effort until early 20th century. The majority of research was still carried out in natural history, with morphological and phylogenetic analysis prioritizing experimental causal explanations. At the beginning of the 21st Century, natural history was substituted by experimental work as the dominant research mode. Technological advances such as diagnostic DNA sequence and polymerase chain reactions enabled biologists to examine the genetic plans which created species. Theoretical and experimental study, including online publication of biological system and science of ecosystems, was facilitated by technological advances. New areas of biological science research thereafter emerged. Biology is thus, rapidly advancing due to advances in technology and emerging global trends.

2.2.3 Overview of Biological Knowledge

Biological science has progressed in knowledge, creative mind and technological advancement. In the early history of Biology, naturalists studied the living world by combined observations from biology, geology, and physics. In the twentieth and twenty-first centuries, the study became more interdisciplinary and integrative, combining previously disparate fields to form a "New Biology." Biology is now integrating knowledge from multiple disciplines for better understanding of biological system. Insight understanding enables the development of biology-based solutions to societal problems while also providing feedback to enrich the individual scientific disciplines that have contributed to the new insights (Fermon et al, 2010).

Biological process ideas must be tested using information obtained from the natural world; It entails critical thinking, careful data collection thorough peer review, and results communication. Curiosity and inquiry are the main drivers behind biological science's advancement. Biologists investigate the living world by asking questions and looking for answers. Science -based responses involves logical, rational and problem-solving method.

With the current technological trends in biology, various scientific investigation is conducted. The introduction of Microscope led to development of Cell hypothesis. Gregor Mandel's heritage studies on garden pea had for many years been disregarded until technical developments that enabled, the chromosomes to be discovered and heritable role to be played. Biotechnology evolved from a mostly descriptive research that concerns whole cells and organisms into a subject that focuses on the study of single cells and organisms. Biology is therefore a rapidly advancing science that contains vast amounts of information about living organisms. The curriculum is designed to help students learn facts while also develop a broad, general understanding of biology principles and concepts. Biology should therefore, be taught in contexts that are relevant to everyday life. The use of a variety of learning and teaching strategies, as well as assessment practices, piques the interest and motivation of students with a variety of abilities and aspirations.

Practical is a very key component of curriculum. It provides students with skills and long term know how through a rigorous and structured process, this enhances mastery of science and improves critical thinking among learners. Similarly, such activities promote scientific thinking, concepts and knowledge for posterity. Students gain an understanding of the nature of science and the limitations of scientific inquiry by participating in scientific investigations (Robbins, 2017).

2.2.4 Introduction of Biological science into the school curriculum

Biology as a science subject has experienced exponential growth and change over the last few years. These changes include the aspect of biological knowledge, the ideology's institution, and the process of biological research. Advances in science and technology have impacted society in areas such as health, horticulture, agriculture, biotechnology, sustainability, and environmental conservation. The complexity of biological concepts with which is confronted, as well as biological knowledge being relevant in our everyday life and the development of functional biological education in 21st-century society is potentially more important than ever before (Bay, 2009).

Biology in the Kenyan curriculum is a vital subject, it influences living standards especially in fields such as food industry, agriculture, education, and significantly the medical field (Okere, 1996). It covers several areas and occupies a considerable proportion of the subjects of learning. This curriculum was implemented in Kenya and was strongly influenced by the 1972 Biology Study (BSCS) of Nuffield, it had broader aims and a course content specific to and therefore relevant to the learners' population from East Africa. In Kenya, the education system is structured to present the topic of biology to all secondary-school students in their basic curriculum (Ituma, 2012). Although some fundamental aspects of biology are taught in elementary education, these concepts are presented in a science-based way during elementary or primary education curriculum. The subject is autonomous at secondary school level. Its concepts, principles, and skills are taught through experimental investigations and a hands-on approach (Okono, Sati &Awuor, 2015). Implementation of the biology curriculum means development of scientific concepts, principles and skills for learning in learners through experimental studies. Discovery is greatly encouraged as well as acquisition of information. Makato (2016) pointed the following: material, practical work, projects, group discussions, excursions and work in the field are necessary tools in biological education.

Biology as a subject has a knowledge-based application element where learners make use of the knowledge obtained in their everyday lives. Basic science biology lies in the lower level of cognitive domain. Its goal is to expand knowledge, while applied science lies on higher levels of cognitive domain, it is based on the results produced by fundamental science. The primary objective of teaching Biology; is to use science in solving real-life problems such as increasing crop yields, finding a cure for a particular disease or saving animals at risk of a natural disaster. Many remarkable applications of high value have been derived from fundamental knowledge. Therefore, there's need to instruct students to link what they learn to what they see in their daily lives in their classroom. Kenya's current secondary school curriculum is practical and comprehensive. It aims to expose students to a wide range of experiences, which results in a well-rounded individual. The goal is to prepare children for vocational and commercial enterprises, as well as fulfill emotional, social, and personality traits (KICD, 2018). According to Okere (1996), students who successfully complete secondary school should have appropriate psychomotor, affective, adequate skills and technical know-how that makes them useful members of the society. The school curriculum that includes practical activities in the learning of biology is the main tool for achieving these attributes. Okere (1996) argues that; Maundu, Sambili and Muthui (1998) support the opinion that a scientist must be able to intellectually resolve issues in relation to causes and effects, and be able to carry out psychomotor skills.

Kenya Institute of Curricula and Development (KICD), strongly recommend the application of an investigative approach to teaching conceptual biology and development of scientific processes and problem-solution skills (KICD, 2015). The theoretic and practical components of teaching and learning biology complement each other like other subjects of science (Mwangi, 2016). While traditional methods can be used to study the subject's theoretical aspects, conducting experiments is a requirement for the study of its practical content. Okono, Sati & Awuor (2015) notes that, teaching through experimental pedagogy helps the teacher to teach effectively and improves learner skills in the scientific concepts. The method also aids in; acquisition of scientific facts, concepts, and principles, as well as the development of the learners' scientific process skills. Maundu, Sambili and Muthwii (2005) pointed out that; One technique to evaluate the aims of biology education is through practical activity where a test of the use of scientific processes, manipulation and scientific talents is supplied. According to Sevilay (2011) students gain the abilities of science by participating in a scientific laboratory investigation.

Practical activity therefore, complemented with theoretic teaching not only generates the appropriate scientific research skills in the science process but it also inculcates the concepts and attitudes required for skilled scientific investigation. The approach to inquiry into teaching can only be improved by applying scientific process skills. The annual science congress at secondary schools, as well as the emphasis placed on student projects in schools, are initiatives designed to help students acquire science process skills.

Kenya 2030, aims to enter the ranks of newly industrialized countries that will promote use of science and technology. This will enhance productivity and accelerate economic development (GOK, 2016). The Science Process Learning strategy in Kenya secondary schools intends to promote the development and implementation of economic start-up of the 21st Century and the science process knowledge needed. The activities in this framework stress a variety of abilities and processes that includes; the value of secondary school biology experimental work, biology lessons approach that promote the solution of problems, project work and usage of materials from the local areas. If these challenge is taken seriously by all secondary schools, many of the graduates churned out will gain the necessary process skills for the country's technical development.

2.2.5 Goals and Objectives of Learning Biology in Secondary School

Scientific education is identified as one of the main foundations of sustainability. According to Robbins (2017) Biological curriculum in particular, is a special field that prepares students enter tertiary courses or work in a field that requires scientific knowledge. Students master scientific skills and technical know-how required to foster a positive attitude, better understanding of life and a competitive world of technology. Biology, as a branch of science, contributes significantly to the world's technological growth (Nnamdi, 2014). It’s important for long-term national development because of its usage in agriculture, pharmacy, ethnobotany, medicine, biotechnology, and other fields.

Millennium Development Goals in conjunction with Biological Science (Fermon et al., 2010) addresses global challenges like climate change, reduction of extreme poverty, potable water, high-quality education and clean energy. This is by; use of synthetic biological materials in search of new material for provision of food security; healthy lifestyle through use of biological medicine; development of water distributions and sanitation for all; clean energy, soil protection, and the use of synthetic biological material.

The study of biology in Kenya, aims to equip learners with the know-how, skills and attitudes needed for individual development and skills to monitor and maintain their environment. According to KICD (2018) biological career allows students appreciate people as part of the larger living being in the community; it is an essential basis for occupations in; health, agriculture, environment, education, medicine, agro-chemistry, food industry and biotechnology (Mukachi, 2005). Biology is a forerunner of biotechnology, an instrument of advancement in industrial technology (Hassard, 2009).

KICD, The National Research and Curriculum Development Center in Kenya identified objectives that should be acquired by a student after the 4-year Biology course at secondary school level (KICD, 2018). Among some of the objectives included are; the ability to accurately, clearly and logistically communicate biological information; the use of knowledge acquired to improve and maintain personal, family and community health; and the development of positive attitudes in relevant practical biology skills. These objectives recognize the crucial role that biology knowledge plays in a country's socio-economic development. The knowledge gained, helps solve problems in society especially in areas of health and the environment.

In addition, KICD (2018) re-arranged and streamlined the current biology curriculum with a strong suggestion for use of research approaches as a broad goal for teaching principles of biology and developing the skills and abilities of science processes. The science-process skills are acquired by participating in research and laboratory inquiries (Zeidan & Jayosi, 2015). Ongowo and Indoshi (2013) suggest that practical work not only engenders the science process skills suitable for scientific research, but also instills concepts and attitudes that are needed for qualified scientific research. The teaching of biology investigation technique can only be improved by applying the know-how of science processes.

Anderson (2001) highlights that, the most essential educational aims are to promote information retention and cognitive processes in the transfer of knowledge learnt to solve problems successfully. Learning should go beyond, simple presentation of factual knowledge (recall factual knowledge) and evaluation tasks. The degree to which students meets the expectations stated by the teachers' objectives is a measure of successful teaching. The instructional strategies that are desired to achieve the desired goal are structured and used. Teachers are vital in the development and support of sequential frameworks that foster good biological understanding through the adoption of various student-centered and teaching techniques that encourage competitiveness. Example, is the field activities and trips. This is significant as it provides a range of possibilities that foster a larger span of knowledge. It allows a participatory and rewarding learning environment. It also provides an environment where new ideas and concepts relevant to biology and its linked fields can be explored and tested. Fieldwork has an enormous and positive influence on the knowledge, perceptions and interaction of students, which are necessary to boost high performance and achieve the goals and objectives of biology, this is according to Nolan (2009).

Cimer (2012), concluded by stating that students of biology can get as much biological knowledge through the methods of lecture or the group method by either random groups or socio-metric groups. From the analysis of '10 best-selling textbooks from 1935 to 1955,' Watson and Blackwood (2008), examined the trajectory towards predicted results of high school biology education; they discovered that the trend in biology was "to address the biological principles that enable students comprehend themselves as creatures and the environment in terms of organ interactions." They further indicated that all students could gain a modern biology course (an adequate understanding of biology concepts); so that those who do not become doctors, nurses, veterinarians, farmers or other careers from biology; can cooperate intelligently with those in the community. The opportunities for a practical grasp of the biologist's method will allow them the confidence to try to solve problems in their individual or societal life, in consultation with professionals.

2.2.6 Bloom Taxonomy for Learning Activities

Experts in the classification of educational goals have made a variety of approaches. The most common system used for classifying the objectives and examination is the one developed by a number of university lecturers and later published in Benjamin Bloom's Taxonomy (Allison, 2010). 'Taxonomy' is a Greek word 'taxis' which means 'order' and 'nomos'. It denotes "orderly arrangement" in the derivative sense (Rajendran, Anandan & Rajendran, 2015).

Bloom established a taxonomy, a framework of higher and lower level (Ball & Washburn, 2001) of thinking that included all the cognitive abilities from lower levels (Anderson, 2013). It is a clear classification that defines six stages aimed at, achieving education objectives and measuring the performance of learning in schools. The cognitive areas are: knowledge, comprehension (understanding), application (use), analysis, synthesis and evaluation (Case, 2013). Assaly and Igbaria (2014) states that Bloom's has numerous characteristics which make it the most commonly used taxonomy in the education field: The taxonomy is educational and can be used to differentiate between target groups that teachers use for writing curricula, study programs and lesson plans; the levels are clearly and logically defined (Bloom’s, 1956, as cited in Allison, 2010). Psychological phenomena are too, described in the taxonomy that means; the process of thinking ranging from simple up to complex, each level resting on the previous level (Forehand, 2010).

The Taxonomy of Objectives, although named after Bloom, was published during a series of conferences with a goal to achieve, better communication among educators with respect to curricula design and assessments (Bloom's, 1956, as cited in Allison, 2010). From, 1949 to 1953; Manual I: Cognitive was produced as the first volume of the taxonomy; in 1956 and, in 1964, Handbook II: Affective was published as the second volume. In 2001, Anderson and Krathwol developed a revised taxonomy for the cognitive domain. The cognitive domain is divided into six target levels in the original version of the taxonomy (Clark, 2010). The levels include: remember, understand, apply, analyze, evaluate and create (rather than Synthesize) (Clark, 2010). The revised Bloom taxonomy model has a two-dimensional structure (Radmehr & Drake, 2018) and the differences between the two versions of Bloom taxonomy is that the remembering level has taken the role of the knowledge aspect in the original version. (Sagala & Andriani, 2019).

Remembering entails recalling of information from memory. Deals with definitions, name, facts, or lists, Students state previous learned information. Students are required to remember concepts of the topics in addition to learning them, this improves cognitive processes Radmehr and Drake (2018)

Understanding means constructing meaning from different types of knowledge learned (written or graphic messages). Entails rephrasing the information learned. The activities in this level include explaining, describing, interpreting, exemplifying and classifying, students express their understanding of facts and ideas (Tekkumru-Kisa & Stein, 2017.

Applying means using a procedure through executing, or implementation in real life situation. Applying relates to or refers to situations where learned material is used through products like models, presentations, interviews or simulations. skills from the "remembering" and "understanding" levels are necessary (Fleckenstein et al., 2016).

Analyzing entails breaking materials or concepts into parts, Comparing and contrasting the connection between the material, determining how the parts relate to one another or how they interrelate, or how the parts relate to an overall structure or purpose. Includes differentiating, organizing, and attributing, as well as being able to distinguish between the components or parts (Watan & Sugiman, 2018).

Evaluating is making judgments about the value of material and methods based on criteria and standards through checking and critiquing. Critiques, recommendations, and reports are some of the products that can be created to demonstrate the processes of evaluation. In the newer taxonomy, evaluating comes before creating as it is often a necessary part of the precursory behavior before one creates something (Tai et al., 2017).

Creating means putting parts and elements together to form a new functional whole. Entails reorganizing elements into a new pattern through innovation by generating, planning, or producing. merge pieces into new forms and propose alternate solutions (Koretsky et al., 2018).

The representation of knowledge dimension as summarized by Anderson and Krathwohl (2001, p.44) is as follows:

Factual Knowledge –is the knowledge of terminology. Factual knowledge is the basic elements students must learn to be acquainted with a discipline or solve problems, composes knowledge of specific details.

Conceptual Knowledge – is the knowledge of classification and categories, principles and generalization, knowledge of theories and structures. It is the interrelationships among the basic elements within a larger structure that enable them to function together.

Procedural Knowledge – How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods. Knowledge of subject-specific techniques and methods. Knowledge of criteria for determining when to use appropriate procedures.

Metacognitive Knowledge – Self-knowledge, Knowledge of cognition in general, as well as awareness about cognitive task including appropriate contextual and conditional knowledge.

Bloom's taxonomy, means that learning at the higher level depends on knowledge and skills at the lower levels (Pappas et al. 2012). The framework clarifies the fit of each lesson plan's purpose, "essential question," goal or objective. The three major areas of Bloom Taxonomy are:

Affective domain – is a field recognized as a significant aspect of learning in the educational curriculum. It is based on the internalization principle. According to (Bloom et al., 1964) the domain includes: learning skills that imply feeling or emotional growth (attitude). Its aim, is to help students develop the factors they learn from such topics as feelings, motivation, attitudes, enthusiasm, perceptions and values. In this area the learner actively listens to the teacher and other learners (receiving); learners participate in group discussions (responding); propose a plan and support ideas for improvement in teamwork (evaluation) and in addition, spend more time studying (organization).

Students need a complete and comprehensive training, so that they don't just gain information and concepts but rather react to what they learn, value it, manage the material and even describe themselves as scientists. Affective fields of biological education are significant for moral attainment. Studies on the attitudes towards science and its impact on student, learning show that students will not want to learn the subject without a positive attitude towards science (Littledyke, 2008). Behavior in this domain constitutes a simple to complex hierarchical structure, divided into five separate categories: receiving, reacting, assessing, organizing and characterizing the complex value (Bloom et al., 1964).

Psychomotor Domain- are manual or physical skills objectives (interpretative movements and reflex actions). This is physical motion and skills to complete a course or topic. In science education, psychomotor goal is very crucial. The biology main competences include: microscope adjustment, diaphragm preparation, handling devices, and field studies that includes throwing a quadrat. Simpson's (1972) categories the levels of psychomotor levels as: perception, set, guided response, mechanisms, complex open response, adjustment and origins.

The purpose of Bloom's taxonomy is thus; to urge educators to concentrate on all the three fields and to create a comprehensive education strategy. These fields are hierarchical because the first activity is a mental process to understand, analyze, synthesize and link information to what is already known. When learning takes place. The process of thought goes into the cognitive field and this is where the study focuses.

2.2.7 The cognitive domain

The cognitive field concerns category and actions associated to; a particular phenomenon, understanding, critical and creative thinking and problem solving

(Forehand, 2010). This area focuses mostly on intellectual knowledge and development. Most work in the curriculum has taken place within this field. Cognitive domain is crucial to assessing the cognitive capacity of students during tests and evaluations. Six levels are included in the domain: knowledge, understanding, application, analysis, synthesis and evaluation. (Bloom, 1956) classified these categories into levels, moving through the lowest order to the highest. It’s a hierarchy in which learners are encouraged to move from lower to higher level of thinking (Pappas et al. 2012).

Figure 2.1 Bloom’s taxonomy model

The model consists of six levels, with the first three levels; knowledge, comprehension and application being the lowest degree of reasoning (Clark, 2010). While the other three levels are categorized as superior as it finds solutions to difficulties in real life. These cognitive levels of thought are the most desired to develop as they improve the ability of the learner to contribute to the development of the individual and society as a whole. High-level cognitive issues require students to have higher-level of thinking or reasoning skills (Pappas et al. 2012). By applying these qualifications, learners recall and utilize not only factual knowledge to solve problems (Gillies et al., 2014).

In the discussion that follow, each of the six categories of cognitive levels are defined and explained in relation to educational objective and assessment practices expected for each level.

Knowledge: (Bloom, 1956) refers to behaviors and test circumstances that stresses on concepts, materials or phenomena like facts, terminology, and definitions, experienced in the educational process. It is information stored in the mind. In Bloom's taxonomy, it is the lowest level. It is only "low" in the sense that it initially occurs; it provides the framework for all "superior" cognitive activity. It requires high-level basic skills that require pupils to obtain exclusive distinct message. A knowledge exam situation determines, whether or not the student can recall or recognize accurate statements in answering certain questions. The form of the inquiry and the needed degree of accuracy should not be too diverse from the original learning, (Bloom et al 1956, p. 62). Knowledge is divided into various categories. Some of the categories are presented below;

Knowledge of specifics is the distinct recall of information or facts in each field of knowledge. It contains information about dates, events, individuals, places, or information sources. They are accurate and detailed data, such as the exact date of an occurrence or the exact extent of a phenomenon. For instance, Biological knowledge is vital if biological processes are to be systematically understood.

Knowledge of terminology refers to specific verbal and non-verbal symbols; this can be defining technical terms. Illustrative question; A synapse can best be described as? Define protandary?

Knowledge of Conventions means characteristic ways of treating and presenting ideas and phenomena. Example is Knowledge of the ways in which symbols are used.

Knowledge of Trends and Sequences are time-related processes, directions and movements of phenomena. The relationship to certain events is highlighted that are separated by time. Examples include the essential knowledge of human evolution, knowledge of the interrelationship of hereditary and environmental elements in order to impact individual development. Illustrative question;

In what sequence are the phases in the life cycle of the locust? 1. Nymph - egg - adult. 2. Adult- egg – nymph.3. egg - nymph– adult.

Knowledge of Classifications and Categories These are categories, sets, subgroups and structures considered essential to a subject area, objective or issue. Illustrative question;

The bio-science branch that deals with cell structure is called? Name the branch of Biology that deals with the study of plants?

Knowledge of Principles and Generalization is recall of the principle as well as the specific illustrations of them. Example is development of an understanding of basic biological principles i.e. cell theory, diffusion, respiration. Knowledge of Abstraction (the recall of major theories about particular phenomena) too represent Knowledge of principles and generalization. Illustrative question; State the possible evidences supporting the theory of biological evolution.

Comprehension: Represent an understanding of the literal message contained in a communication. It's the lowest level of understanding. It demands students to configure the details in their own reasoning, map them in categories, select items in groups, scrutinize and contrast to ascertain the relationship to the works of other areas of knowledge. Entails, understanding and putting facts into your own words. For instance, students cannot just name the cell components but they should also understand the function of each component. (Anderson & Krathwohl, 2001). (Bloom et al 1956, p. 91) divided Comprehension into three categories as follows;

Translation: involve making different parts of a communication meaningful. The ability to translate a problem into concrete or less abstract in technical terms. i.e. "In your own words, state the problem." Which of the following represents the best definition of the term "protoplasm"?

A- A complex colloidal system made up of water, proteins, and fats.

B- A complex mixture of proteins, fats, and carbohydrates, capable of responding to changes in its environment.

C- A complex system of colloidal proteins, lipids, carbohydrates, inorganic ions and life-forming enzymes.

Interpretation: means breaking knowledge into basic and understandable words for an individual's reasoning. The information or thoughts are explained or summarized. Illustrative question is: Explain the adaptation of the skin to its function?

Extrapolation: involves estimating or predicting the patterns and situations described by the data based on comprehension. It is drawing and efficiently stating findings. An illustrative question is: Describe how the experiment on food test confirmed the presence of starch.

Application: this is the application of ideas, norms of procedure or generic methodologies. It involves the use of experimental methods to solve problems. In new situations, students employ their knowledge and talents. The test situation with regard to the application must be new situations for the student or situations with new aspects in relation to the situation in which the information has been learnt. Students are required to solve a problem in their material; provide a plausible solution or, use a visual to illustrate a concept. The student can address practical difficulties by using previously understood material. Illustrative example; develop some skill in relation to Mendel's laws of inheritance to experimental findings on plant genetic problems. (Bloom et al., 1956 p. 120)

Analysis: is the breakdown of complex material into its simpler parts, and recognizing the relationships between the parts and the way they are organized. Here, students go further than the level of knowledge, comprehension and application. They see patterns they can use to analyze a problem. It includes; the dissection of ideas and material in its parts, it involves the methods and tools used to relay comprehension or generating a final communication. Analyzing evaluation of a test can be, a scientific experiment description or a situation where students are placed in a laboratory and the reactions of materials are analyzed.

Its divided into three types according to (Bloom et al 1956, p.145) as follows;

Analysis of Elements is the breakdown of material into its constituent parts, it's the ability to recognize unstated assumptions.

Analysis of Relationships includes determining certain links between elements and the interactions between different communication portions. It is the ability to recognize linkages between cause and effect from other relations.

Analysis of Organizational Principles is a structure and arrangement that holds communications in general together.

Illustrative questions in this domain include: Distinguish between Class Chilopoda and Class Diplopoda. Compare and contrast eukaryotic and prokaryotic cells.

Synthesis: Puts together bits of (elements or components) for establishing a whole and new relationship. Its creating a new meaning. It entails working with and arranging components, pieces, elements and recombining them to form a new pattern or structure. Students draw elements from different sources and put them together. It comprises the ability to incorporate research results into an efficient problem solving plan or solution; or the ability to synthesize biological knowledge and data accessible to the literature and apply these in designing a biological process in the operational process units. Example: Develop the taxonomies for classifying plants and animals. (Bloom et al 1956, p.162).

Evaluation: Cognitive sphere of the highest degree. It's the results of major processes based on criteria and standards for assessing the amount and effectiveness of information. It compares a product with a standard. It is a complex process which involves all other behaviors of knowledge, understanding, application, analysis and synthesis. Students evaluate/judge and conclude the worth of information. The learner must critically assess the validity of the research learning and assess its pertinence. Students, under evaluation level are given a problem during an examination, and are asked to find the logical conclusion and assess the logical precision of the conclusions. One, assesses the materials based on selected criteria. Comparisons of important theories, generalizations and facts are included. (Bloom et al 1956, p.207). An illustrative example in this domain include: Justify and evaluate the statement: The cell is the basic unit of life.

In conclusion, development of learning skills in teaching/learning should never be taken for granted. In foundational classes and intermediate level, teaching of skills related to lower-level processes should be introduced. While, competences related to processes of higher levels should be introduced and reinforced in higher classes (Kim, 2005). A way to highlight the quality of learning is also through, fundamental approaches to learning abilities from diverse process fields across the cognitive field. Better performance is feasible, irrespective of the level of learning skills (Hoque, 2016).

2.2.8 Assessment within Bloom's Taxonomy

Bloom's taxonomy is used develop assessment questions that incorporate multiple levels of mastery and are of varying degrees of difficulty. Education focuses on improving human thought but this cannot be achieved by chance, it must be sought actively (Fahim & Reza Ghamari, 2011). Forehand (2010) asserts that teachers need to embrace and appropriately use the Bloom classification of intellectual behavior in order to effectively measure their students' abilities (1956). The main goal is to organize mastery in a hierarchy from less to more complex (Huit, 2009). A student must first master knowledge at a lower level to achieve it at the next higher level (Kings et al.,2013). The Blooms taxonomy can therefore be utilized in the following specific areas: Set learning objectives and revisions, plan curricula, identify easy-to-most difficult skills, align objectives to assessment techniques and standards effectively, incorporate learning knowledge and in setting of questions (Giesen, 2014).

Bloom's Taxonomy is a tool for planning examination questions, it ensures lower and higher cognitions are included (Alison, 2010). The taxonomy has been used to evaluate appropriate coverage of cognitive levels in test papers. The approach provides a framework for teachers to arrange a sequence of learning experiences for each level before moving to the next level (Alison, 2010). Each level has educational consequences. If the learning process is launched at higher taxonomic levels, processes at lower levels must be integrated carefully into tasks. This is why Bloom taxonomy has become an instrument in the construction of textbooks (Booker, 2007).

Bloom taxonomy provides a framework in which teachers can formulate questions and choose and design tasks which will ensure that various types of cognitive process are included, particularly in context where teaching concerns are mainly characterized by information reproduction and procedures replication. Bloom's Taxonomy is thus seen as a good guide for increasing repertoires of teaching. It provides instructors with a conceptual framework to improve common intelligence and meaningful dialogue. It gives teachers a way to better understand and use this understanding to improve assessment and teaching, it improves the vital connection between them. (Anderson, 2005).

A culture of questioning increases student learning, improves decision making and resolves problems. When people exchange and debate ideas, they become critical thinkers (Garrison, 1992). Critical thinking is encouraged by open inquiries and relates to profound learning (Garside, 1996). Critical thinking depends on an adequate knowledge basis. The lower cognitive levels help pupils gain basics of knowledge (Knowledge or Comprehension objective). Higher levels (application, synthesis, and evaluation objectives), on the other hand, enable students critically reflect the acquired information and build meaning in real-life environments (Biggs, 2001). Constructive alignment is therefore vital in supporting students acquire the required abilities and understanding by aligning the methods of instruction, assessment, and the classroom environment. The teacher should decide the type of question to use for correct assessment of each goal and level of cognition (Fives et. al., 2013). As Bloom (1956) says teachers' must know or at least take certain presumptions about those situations of learning, which went ahead of the test. The teacher, should also try to solve the test issue and note the mental processes required.

The teaching and learning models are expected to be used by curriculum designers and educators. Kim (2012) comments on the relevance of Bloom taxonomies: it is a good practice for educators to use the taxonomy for testing, as it ensures conformity at all levels within the education standards. Various research studies have been conducted on the use of Bloom taxonomy in constructing test items:

Studies of examination in Zambia indicate that most Zambian examinations were assessing low order skills and that educators did not know whether they used Bloom's taxonomy or not as they prepared examinations (Sichone et al.,2020).

Wambugu (2009) analyzed the type of questions teachers set for formative assessments in Kiambu county, Wambugu (2009) found that knowledge and comprehension were assessed in all the eight (100%) of the sampled papers. The research study also found that application was tested in six (75%) of the sampled papers. Two (25%) of the past assessment tools tested synthesis while evaluation level was only assessed in one (12.5%) of the past examination papers. Another related research conducted by Kwaka (2003), revealed that in low performing schools, teachers of Mathematics evaluate learners more on comprehension (58.5%) and less on knowledge and application.

Although the reviewed literature focused on formative assessment, no assessment has been conducted in KCSE Biology summative assessment. This research therefore sought to fill this gap.

2.2.9 Bloom’s Cognitive skills in learning biology through KCSE Biology questions

The harmonization of cognitive knowledge in class activities and test strategies is critical for effective course design (Forawí, 2016). If classroom lessons focus on ideas needing HOCS but test only on factual information of recall, students will learn that they don’t have to make efforts to acquire the content at a high level. Similarly, if the classroom lesson, cover facts and details at lower levels but test at a higher cognitive level, students fail in exams because little practice is provided to establish an in-depth conceptual comprehension of the content. While much focus was devoted to the change of school systems to integrate more active learning practices, less attention was paid to how evaluation systems may be better aligned with the learning objectives. Indeed, improving our evaluations is one of the main strategies to influence the quality of learning (Entwistle & Entwistle, 1992).

Bloom taxonomy is broadly applicable; the classifications has to be defined within the context of the field of each discipline. Bloom's has been utilized in Biology to construct rubrics to evaluate the student performance in introductory biological examinations, (Allen & Tanner 2002). Allen & Tanner (2007) stressed however that, it is important for biology educators to use comprehensive strategies for assessing student learning, guide development of teaching strategies, and promote student meta-cognition in biological sciences.

Bloom (1956) described cognitive learning as "recall or acknowledging information and intellectual skills improvement." The cognitive field includes six subdomains related to the development and learning of our mental skills. The ability to retrieve data and/or information lies in the knowledge level. Assessing learners under this level in Biology requires them to receive a re-calling task under circumstances that are comparable to those in which the material was learnt.

Comprehension involves understanding what is known. Students are required to understand the concepts of biology where they build meanings out of instructional messages like oral, writing and graphic communications. Application level links "new" knowledge and the past knowledge (Brazil, 2001). It employs abstracts or use information in new situations. Evaluation in this area calls for students to create or offer examples. Analysis means that facts and views can be differentiated, and be broken down into its constituents' parts.

The synthesis sub-domain suggests that, diverse components or concepts is integrated in order to create a sound pattern or structure with a new meaning. Creativity in this domain is required, it means creating new ideas. Such a way of thinking is one of the most complicated. The highest sub domain, evaluation, comprises the ability to judge the relevance of concepts: Criticism of the evaluation of biological concepts, principles and knowledge based on criteria and standards is extremely imposed. In criticism, a student takes note of the positive and negative characteristics of a product and evaluates at least partly these characteristics. Invitation to criticize involves critical thinking (Krathwohl & Anderson, 2009). In dealing with the cognitive domain, it is easy to specify desired types of student behavior such as the subject-matter content of Biology instruction.

The third level of the cognitive domain (application) is considered as a shift from LOCS to HOCS. (Stanger-Hall, 2012) states that the three categories (analysis, synthesis, and evaluation) require mastery of LOCS and for one to respond properly to a question, it is considered useful to check every level of Bloom's taxonomy.

Cognitive level of Bloom assessed by a given type of exam question depends on the information learned by the student and the connections the student make on their own. It is therefore important to consider the level of information previously provided through classroom instruction. For example, if students are given an answer to an analysis question in class and then given the same question on an exam paper, then the same question only requires recall (Stanger-Hall, 2012). Crowe, Dirks & Wenderoth

(2008) argues that labeling diagrams, figures cannot evaluate more than the degree of application, because at the maximum this form of question demands students to apply their knowledge to a new situation. However, filling blank spaces and multiple choice questions falls at the analysis level. There are many resources available to help examiners develop high-grade examination (Brady &Collier, 2010). According to Crowe, Dirks & Wenderoth (2008) the Bloom Taxonomy tools do not constitute an absolute or permanent rubric; its intended to be employed as a basic guide for developing and identifying biology-related questions representing the different levels of Bloom's.

Many researchers and teachers agree that for holistic students' academic achievement in biology, it should not be only what students remember but also what students are able to do with their skills. Memorization and recall of information are LOCS that require only a minimum amount of understanding, whereas application of facts or concepts and critical thinking is a higher degree of cognitive knowledge which requires a deep conceptual grasp (Bramwell-Lalor & Rainford, 2014). All cognitive domain levels should therefore be learned, tested and evaluated in the examinations.

The literature of Biology examination studies shows that, the majority of teacher tests just required retain of information (Plax & Kearney, 2016). However, secondary teachers (McMillan, 2001) argue that, they quite often assess the application and higher order levels. The reason that test questions at lower levels are so frequent is because, it is easier to set. They are also the easiest questions asked in the classroom. This research study therefore, seeks to investigate the cognitive levels present in KSCE Biology examination with a view of determining the extent to which it covers the higher levels of learning.

2.3 To Determine the Extent to Which KCSE Biology Questions Seek Development of Higher Order Cognitive Skills

Cognitive skill is classified into groups: Higher order cognitive skills and lower order cognitive skills (Clark, 2010). Lower order cognitive skills include knowledge, understanding and application. Higher order thinking skills are the higher three aspects of Bloom taxonomy which are; analysis, synthesis and evaluation (Moore et al. 2010). Blooms Taxonomy therefore, involves intelligent thinking, problem solving, creativity and critical thinking (Lewis & Smith, 1993). Its reasoning in a way of finding new difficulties (Heong, et al 2011). Dewey (1933) says that thinking is not spontaneous, but "unfamiliar difficulties, questions, conflicts, and insecurities must be evocative”.

Brookhart (2010) defined the four categories of HOCS as follows: information or knowledge transfer, critical thinking, creative thinking and problem-solving. Norris (1989) further defined HOCS as a plausible concept and reflective thought based on critical thinking which is geared towards determining what we can do or believe. Students who are critical thinkers don't conclude but quickly learn by thinking logically. Creative thinking mainly deals with synthesizing (Barak et al., 2007). It’s bringing up a new idea of value that was not in existence.

Creative learners develop, implement and communicate new ideas to others. They demonstrate originality and inventions in their work. Students apply new information or knowledge that they learned and manipulates the information to reach the possibility of answers in new situations (Zoller, 2002; Zohar & Dori, 2003). Problem solving is defined as; thought process utilized by students to achieve a goal or make solutions for a problem (Mainali, 2012).

The HOCS characterized by knowledge transfer occurs when students don't simply recall but analyze what they learned, rationalize it, and apply it in class (Anderson &

Krathwohl, 2001). HOCS learners use scientific material to produce multiple solutions in practical circumstances. Several biological problems also demand techniques of experimental solution (Ehmer, 2013). The implementation of problem-based active learning models has a positive impact on academic achievements of students and their attitude in science (Asyari et. Al 2016). It also promotes students' critical thinking and provides solutions to problems (Da Silva, 2014). Development of higher thinking skills should be based on lower level skills (Clark, 2010). Lower-order cognitive skills (LOCS) requires only a minimum degree of intelligence (recall of the past knowledge). Better cognitive skills are therefore facilitated by, appropriate teaching tactics and learning environments. With this, students acquire; tenacity, self-monitoring and open-minded, versatile attitudes that can make a beneficial contribution to the environment and community at large.

Facts and data are not only needed for 21st century, as information is always changing, updating and developing (Kauchak & Eggen 1998). The important attributes therefore, needed for a 21st century learners include; strategic thinking, effective communication, use of metacognition, problems solving, ability to make inference, logical thinking, creation and innovation. Robbin (2017) therefore emphasize that students should: develop scientific and creative thinking abilities; learn analytical thinking in order to analyze critically topics related to biology; recognize the use of biological knowledge in informed decision-making.; Acknowledge the relevance of the facts given, to support, alter or refute scientific ideas; make thoughtful comments, ask pertinent queries, discover difficulties and build investigative hypotheses; Plan and carry on scientific studies with appropriate instruments and methodologies independently or jointly; accurately gather quantitative and qualitative information, analyze data and develop conclusions on problems; and lastly, communicate and use science language effectively. If these is adequately thought and nurtured in our school curriculum, students grow their intellectual skills, gain biological knowledge, and their science concepts and process skills are developed. However, this is only possible if both higher and lower cognitive skills are sufficiently reinforced (Clark, 2010).

Various research studies have been conducted concerning higher order thinking skills with respect to students learning. Foong (2000) in Singapore conducted mathematics research on open-ended problems for higher order thinking. Murray (2011) in Georgia analysed the implementation of higher order thinking in the middle school mathematics classrooms. Ghasempour et al., (2012) in Malaysia did a research on higher order thinking via mathematical problem posing tasks among engineering students. The results of these research conducted indicated the importance of developing higher order thinking skills among learners to enable them face the challenges of daily life.

Masinde (2012) conducted a study on Application of Blooms taxonomy in teacher made tests in secondary schools in Kenya. He examined the extent to which they reflected high level learning, critical thinking in meeting the 21st century skills. The findings from the results were such that teachers tended to ask questions in the 'knowledge 'category most of the time, teachers developed examination questions that do not match the required mental process and knowledge dimension.

Although, many researchers have discussed and investigated broadly the role of higher order thinking skills with respect to student learning, little is known about the extent to which examination bodies in Kenya assess the higher cognitive skills. This study therefore, sought to provide this missing information.

2.4 Related Research on Analysis of Questions Using Bloom Taxonomy

Research studies have been conducted worldwide with respect to the cognitive process skills and knowledge dimensions in Science education: Karamustafaoglu and Bacanak (2010) classified Biology exam questions according to Bloom taxonomy in four Turkey cities, the sample of the study comprised of 28 biology teachers in 12 secondary schools. The study was conducted between 2007 and 2009, 615 biology questions were assessed. The results indicated that majority of the question were lower-order cognitive skills.

Turkey chemistry examination questions from three high school in Trabzon and Amasya, were studied and compared by Karamustafaoglu et al. (2003). Four hundred and three questions were gathered and examined, 96 percent of the questions analyzed were LOCS. However, statistical analyses revealed that the questions compared with those of the university entry exam, show that more than half of university entry exam questions are HOCS. These results demonstrate the vast variations between the evaluation at high school level and at the university entrance exams.

Azar (2005) examined and compared high school physics and university exam problems. The examination questions originated from two sources; 76 questions on physics from university entry tests from 2002 to 2003, and 556 physics questions from physics lecturers. The findings from the research indicated that, Physics questions in the college entrance tests are based on the cognitive abilities of the upper order level (analysis, evaluate and synthesis) while the secondary school questions only measure the students lower order cognitive skills (of Remember, understand and apply).

The Bloom's taxonomy questions were categorized in the United States by Zheng, Lawhorn, Lumley, and Freeman (2008). The research analysis came from five sources;

The biology section of Medical College admission test (MCAT), AP biology, Biology introductory course of undergraduate students of three universities, Biology-Graduate Record Examination (GRE), and five medical school first-year courses from an institution with a traditional curriculum. The study demonstrated that, most of the questions examined were lower cognitive skills. A large share of the examination was at the comprehension level. Several questions on application were also included in the research data. All the exams required analysis, but in the first-year exams of the Medical School the proportion of these problems was far fewer. Very few questions required the synthesis domain. Evaluation-level questions were completely absent from the research data (Zheng et al., 2008).

Ulum (2016) conducted a content analysis study on the extent of Bloom's taxonomy in the reading comprehension questions of the course book "Skills for success, of reading and writing" Findings from the research indicated, few higher cognitive skills of Bloom Taxonomy present in the course book.

Cullinane and Liston (2016) conducted a survey on Bloom's taxonomy on certificate Biology examination question (1999-2008). The findings from the review strongly imply that majority of the questions did not tap on the higher levels of thinking (Cullinane & Liston, 2016).

In Kenya, Nguthiru (2013), identified challenges faced by teachers when using Bloom's Taxonomy in setting school-based Mathematics tests in secondary schools of Njoro district, Kenya. The data analyzed was from one to three end-year examinations and form four classrooms pre-mock. The majority of the test questions in Njoro's secondary schools lied towards Application (28%) and Analysis (22%) skills of Blooms' cognitive domain. The survey noted that Bloom's concept of Mathematics has not been applied by most of the mathematics teachers in Njoro high schools' tests. The study revealed Mathematics teachers' ignorance on use of Bloom Taxonomy concept.

Gichuhi (2014) examined on the competence of secondary school teachers or instructors in assessing their learners, by finding out whether when developing tests and examinations are guided by the Bloom's levels of cognitive objectives. The design for the research was a cross-sectional survey where a sample was selected from the target population of all the public secondary schools within kikuyu District. The findings revealed that, high school teachers do not adequately employ the Bloom's cognitive domain in constructing their test items. It also reported that teachers do not adequately make use of the action verbs in constructing test items. In all the schools the results were comparable.

Masinde (2012) investigated the extent to which quality test administered in schools in Kenya reflects high level learning; and critical thinking in achieving the 21st century skills as listed in blooms taxonomy. The results show that teachers ask questions in the 'knowledge 'domain most of the time, they construct examination test that do not match the required mental process. Only knowledge dimensions' test results in poorly constructed paper.

Wambugu (2009) analyzed the type of questions teachers set for formative assessments in Kiambu county, Wambugu (2009) found that knowledge and comprehension were assessed in all the eight (100%) of the sampled papers. The research study also found that application was tested in six (75%) of the sampled papers. Two (25%) of the past assessment tools tested synthesis while evaluation level was only assessed in one (12.5%) of the past examination papers.

The above, are some of the gaps that this research has been able to establish from the study in this field. The finding that examination is set without a guide is quite evident. Recall questions is not an incentive to increase student thinking and problem solving abilities. Mkandawire (2013); Kanter (2013); Kim et al., (2012); Krathwohl (2002) argues that, the absence of a systemic framework (Bloom's taxonomy) in writing educational objectives and setting of examination papers indicates that quality is not apparent, or verifiable, and the intended results could be inappropriate to student behavior.

Boud (1995) states that the certification evaluation has been concentrated more than the learning aid assessment which is against the main goal of education of producing critical thinker learners. Examiners should concentrate on all levels of Blooms cognitive domain in both test construction and classroom learning objectives. This will aid in ascertaining whether the appropriate skills and information has been acquired by the learners. It is against this backdrop that a research study to evaluate the cognitive domain of educational objectives in setting examinations has been undertaken.

2.5 Summary

This research is crucial, as it sheds light on the KCSE Biology examination standards; it gives examiners an instrument for examining weaknesses and strength of the assessment. Similarly, an analysis such as this provides a good insight into how well learners, schools and teachers do to assist students reach standards when evaluation conforms to the criteria (Herman, Webb & Zuniga, 2007). Moreover, in order to gauge the attainment of the curricular standards, Olson (2003) states the importance to evaluate the relevance of the test to the extent of those standards represented. Therefore, this research fills the gap in the scholarship in this area and serves as a future benchmark for further research on the analysis of biological studies. Similarly, this study put forward in-depth recommendations that will go a long way in improving science notably biology as an important discipline in the country.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter entails: Research design, study focus, sample selection, data collection instrument, piloting of the study, credibility, transferability and dependability of the research, data analysis, ethical consideration and summary of the chapter.

3.2 Research Design

The study adopted mixed-method approach. Mixed method research is the type of research in which elements of qualitative and quantitative research approaches are combined (Johnson et al. 2017, p.123). Quantitative method was used to explain qualitative data, this involved creating codes and themes qualitatively then counting the number of times they occur in the text data. The quantitative results were then summarized and interpreted. Creswell and Plano Clark (2018) argue that integration in this design takes place by connecting the quantitative findings to the qualitative data collection after qualitative phase is complete.

Qualitative content analysis, a method of systematically investigating texts or information expressed in words was used and given a lot of weight in the research process. Newman (1998) assert that, qualitative content analysis is authentic and detailed enough, it's also easier to interpret because it is more specific and explicit rather than implicit in nature and the more details of cases under it produces richer data and more meaningful findings. Roller and Lavrakas (2015) defined qualitative content analysis as “the systematic reduction of content, examined with special attention to the context in which it was created, in order to identify themes and extract meaningful interpretations of data” (p. 232).

According to Leavy (2017) Content analysis involves initial immersion into the content to get a sense of the “big picture,” determining the units of analysis, coding, analysis, and interpretation of data. This qualitative content analysis went beyond merely counting words to examining content intensely for the purpose of classifying large amounts of text into an efficient number of categories that represent similar meanings. Therefore, the goal of using content analysis was to provide knowledge and understanding of the phenomenon under study (Cohen, 2018).

3.3 Study Focus

The study looked at past Biology KCSE paper one, two and three from 2008-2018. Nine hundred and forty-eight questions from paper one, two and three of KCSE Biology was analyzed. Analyzing the eleven years allowed the researcher to obtain extensive information about the study.

3.4 Sample Selection

The sample for this research comprised KCSE Biology examination dating from 2008 to 2018. Two hundred and eighty examination questions consisting of sub-questions of three different papers were purposively selected. The examination questions were identified as information rich (McMillan &Schumacher, 1997) to be used for this research. Purposive sampling technique was therefore used in the research as the units selected had the characteristics needed in the sample (Shaheen et al., 2016).

3.5 Data Collection Instruments

The most important source of data for the study was past examination papers whose question items were analyzed.

3.5.1 Document Analysis

This is critical examination of public and privately recorded information related to the issue under study (Corbin & Strauss, 2008). It is used to obtain unobtrusive information without interrupting the research. Document analysis enabled the researcher to obtain information in its total originality. It also enabled the researcher obtain information and data at convenience. The data and information obtained through this method were thoughtful because the researcher did it thoughtfully and gave special attention to compiling the document while ensuring that the information contained in it were factually correct.

Bloom's Taxonomy was used as the guiding principles in analyzing the Biology question papers to the various levels in the cognitive domain. The objectives in each question was interpreted based on action verbs prescribed in the Blooms' Taxonomy and assigned to the relevant level in the cognitive domain. The number of objectives at each level for all the questions in a given Biology question paper was then totaled and expressed as a percentage of the total number of objectives in the question paper under consideration.

While Bloom's Taxonomy and suggested action verbs formed the guiding principles in assigning marks for each item to levels in the cognitive domain, in most cases items were critically examined in terms of the expected outcomes before assigning to a particular level. For the past biology KCSE examination papers, the totals under each level in the cognitive domain for all the papers was taken added and expressed as percentages of the total marks in all the papers

The division of test questions into lower order cognitive skill and higher order cognitive skill questions (Tsaparlis & Zoller, 2003) was also applied in the research. The examination questions that required students to use higher-order cognitive skills were classified into one of the three highest Cognitive domains (Analyze, synthesis, Evaluation) while the questions that only required simple recall of information were classified into one of the three lowest Cognitive Process categories (Knowledge, comprehension, Application).

3.5.2 Data Collection Procedure

The researcher obtained clearances from the University to carry out the research study. Document analysis was employed as a tool to collect data. For the purpose of this study a checklist was used to record and tally the cognitive levels of the questions collected from Biology KCSE examination papers.

The researcher built a checklist based on Bloom's Taxonomy of the cognitive domain. The checklist was composed of a table with nine columns. The first column contained the serial number of the question; the second contained the question, while each of the following six columns contained one of the six cognitive levels of Bloom's Taxonomy placed in sequence from low to high. The last column constituted number of marks assigned to the cognitive domain.

Table 3.1: Bloom Taxonomy Checklist

NO	QUESTION	KNOWLEDGE	COMPREHENSION	APPLICATION	ANALYSIS	SYNTHESIS	EVALUATION	MARKS
MARKS								

The checklist was combined with explanatory sheets that contained two tables: a table in which a definition for each of the six cognitive levels and examples on the verbs used for each level, and a table with example questions and activities on each level. The tables were added to make it easier for the researcher to decide the cognitive level of each question coded. Questions that required recalling of biological facts, observation, or definitions were coded under knowledge-based, while questions that required organization of facts, such as order of 'describe', 'explain', 'compare' or 'contrast', and 'state' were coded under Comprehension level. Questions that encouraged learners to apply information taught or learnt to solve a problem were coded as Application of biological knowledge. Questions that helped learners to establish underlying reasons such as causes and effects were coded as Analysis level. Understanding of the subject matter and relationships such as questions on 'construct' or 'develop' were coded as Synthesis domain. The questions that needed students to make judgement and justification of knowledge learned, were coded as the evaluation domain.

Table 3.2: Bloom Taxonomy Verbs

Cognitive level	**Definition**	**Action Verbs**	**Level**
Knowledge	Recognition of facts and information	Name; list; state; sketch; define; identify; Label	Lower order
Comprehension	Understand the meaning of the information	illustrate, discuss, highlight, recognize, show, explain, predict, review.	Lower order
Application	Ability to use knowledge in real settings	Apply, Change, Choose, Compute, Prepare, Produce, Select, Show, Transfer, Use	Lower order
Analysis	To break down into parts; Make a relation to the assumptions	Distinguish, examine, outline, related analysis, classification, compare, contrast, deduce, diagram, differentiate, Research.	Higher order
Synthesis	Reorganize ideas into an entire new component	Compose, Construct, Create, Design, Develop, Integrate, Invent, Make, plan, Organize, Produce, Propose, Rewrite	Higher order
Evaluation	judge the value using definite criteria	Appraise, Argue, Assess, Choose, probe, Decide, Assess, specialize, Predict, Rate, Review	Higher order

Table 3.2 shows the cognitive level and the examples of the verbs used in each level.

Table 3.3: Bloom cognitive domain, learners' activities

Cognitive domain	Assessment	Learners activities
Knowledge	• Remembering terms, facts, concepts, specific items of information • Fill-in-the blanks • Memory activities	• List • Name • State • Write definitions • Label
Comprehension	• Provide examples • Diagrams • Create a summary • Essay	• Explaining ideas • Summarizing material • Understanding facts • Giving examples • Giving reasons
Application	• Applying concepts and principles to new situations • Applying laws and theories to practical situations • Solving of mathematical problems • Constructing charts and graphs • Demonstrating correct usage of a method or procedure	• Graph • Applying ideas to new situations • Conducting experiments • Practical applications of learned knowledge
Analysis	• Breaking material down into component parts • Analysis of relationships between parts • Understanding both the content and structural form • Analysing the elements	• Compare and contrast • Distinguishing between facts and inferences • Evaluating the relevancy of data
Synthesis	• Develop criteria to evaluate product or solution • Putting parts together in a new whole • Formulating new patterns or structures • Abstract relationships • Creating new or original things	• Develop and describe new solutions or plans • Research projects • Finding new combinations • Showing how an idea or product might be changed
Evaluation	• Ability to judge the value of material • Use of definite criteria for judgments • Critique hypothesis, procedures • Outline alternative solutions • Research report	• Generate criteria to evaluate • Review paper • Rating ideas • Accepting or rejecting ideas based on standards • Judging the logical consistency of written material

3.6 Piloting of the Study

Pilot method is an initial run-through of the procedures to be used in an investigation. According to Orodho (2009), research instruments need to be tested to ensure that information and data obtained is consistent and accurate. Piloting involved selecting a few examination questions and trying out the research instruments. MOCK examination was used for pilot study. Mock examination for Biology subject was computed and analysed. Credibility, transferability and dependability of the research process was then determined as follows:

3.6.1 Credibility of the Research

Credibility is the confidence that can be placed in the truth of the qualitative research findings (Holloway & Wheeler, 2002) Credibility establishes whether or not the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original view (Graneheim & Lundman, 2004). Credibility of the research was determined by the researcher through the coding practice in order to enhance the consistent interpretation of data and reduce individual interpretive biasness (Creswell, 2007). Hence, before coding the examination questions, three researchers were requested to practice coding independently until 90% or greater reliability of coding was achieved. Differences in coding was constantly compared, discussed, and resolved to meet the level of consistency. At this point, a coding book was developed for use during the remaining data analysis. Additional coding rules was defined to establish consistency in segmenting the descriptions for coding. Bloom's definitions of different levels of the cognitive domain was carefully studied and the key word examples was extracted and used. The coding scheme represented the six levels of learning objectives. Once the data had been coded, regularities, variations and peculiarities were examined and patterns identified. The process of identifying substantive connections by associating codes or linking data was done (Dey, 2003). Correlations or relations between different codes was studied and a picture of the data build.

3.6.2 Transferability of the Research

Transferability refers to the degree to which the results of qualitative research can be transferred to other contexts with other respondents, it is the interpretive equivalent of generalizability (Bitsch, 2005; Tobin & Begley, 2004). This was facilitated through thick descriptive data. Detailed description of the application of Bloom taxonomy, its usage and application was done. Provision of background data to establish context of study and detailed description of phenomenon in question to allow comparison with other study was made (Shenton, 2004).

3.6.3 Dependability of the Research

According to Bitsch (2005), dependability refers to "the stability of qualitative research findings over time". Dependability involves participants evaluating the findings and the interpretation and recommendations of the study to make sure that they are all supported by the data received from the informants of the study. Review by Biology examiners was used to guarantee the dependability of the research. Twenty-eight Biology examination questions was picked at random and analyzed by another research scientist who is specialized in the field of biology education and has a deep understanding of the Bloom's Taxonomy and its usage as a classification tool. The classification procedure demonstrated by categorizing some example questions together prior to the peer review was done to achieve good common understanding about the classification process.

3.7 Data Analysis and Presentation

The content of the examination questions was interpreted through the systematic classification process of coding and identifying themes or patterns (Hsieh, & Shannon, 2005). Coding as a process of organizing and sorting data was used. The data collected was edited, coded and classified on the basis of similarity and then tabulated. Cooper and Schindler (2014) assert that the core function of the coding process is to create codes which could then be summarized and analyzed from simple recall or recognition of facts, as the lowest level, to more complex and abstract mental levels of analyzing and evaluating.

This research examined the levels of Bloom's taxonomy used in the Biology examination of 2008 to 2018. Generally, each question was matched with the cognitive thinking levels of the Bloom's taxonomy and in this particular research, question key words was used. Key word in each examination questions were identified to determine the extent the questions involved cognitive thinking levels and in order to do this, descriptive analysis for each question was done. All the questions between 2008 and 2018 examination questions were collected, listed, and analysed according to Bloom's taxonomy. The percentage and frequencies were calculated for each level of cognition. The data was presented in the form of tables for ease of reference. In each table, raw frequencies as well as the percentage for each cognitive level was provided. Question stems focusing on each level and keywords exemplifying the steps of the taxonomy was used to come to a conclusion on the levels of thinking order available in the examination questions.

The data that emerged from descriptive analysis, for example frequencies and percentages, was employed in data analysis.

3.8 Ethical Consideration

The researcher sought permission from the University (Appendix III). A research permit was also obtained from National Commission for Science and Technology Institute (NACOSTI) to conduct the research (Appendix V). As noted by Kothari (2004) it is appropriate to seek permission from relevant stakeholder before data collection in any scientific research. Several other ethical considerations were considered during data collection, representation and sharing research findings. The primary considerations involved disclosure of the methodology, the format of the representation, and how the information was presented. Disclosing the methodology involved explaining and justifying research design procedures and the methods employed (Leavy, 2017 p.43). Methodological transparency was considered important so that those exposed to the research understand the process by which conclusions were formed. According to Creswell (2014 p.132) the researcher should avoid falsifying authorship, evidence, data, findings, and conclusions. Therefore, no work was plagiarized. Creswell (2014) further insisted on communicating in a clear, straightforward, appropriate language. Unbiased language appropriate for audiences of the research was used. Honesty and truthfulness were the keys throughout the research process. Responsibility to the profession including accuracy in analysis, presentation, and reporting of the study findings was adhered to. Respondents were therefore assured of confidentiality of the information provided.

3.9 Chapter Summary

This chapter has described the methods used in the study. The research which is very important to the research process was also discussed here. Study population, study focus, sampling technique, data collection methods, pilot study, credibility, transferability and dependability and data analysis was also covered. The research tools in the study was found to be appropriate in conducting the research. Ethical issues were also discussed.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, INTERPRETATION AND DISCUSSION

4.1 Introduction

This chapter presents the analysis and explanation of the data of the distribution of 2008-2018 KCSE examination questions along Bloom's taxonomy. Explanation of the data is a very important part of all research as it simplifies the results on the whole population. Content analysis was used to analyze the data. Tables and bar graph were used to illustrate the data that is arranged in percentages and frequencies. The research findings, interpretation and discussion is as per the following objectives: To analyse the KCSE Biology question (2008-2018) in light of Bloom's cognitive domain. To determine the extent to which KCSE Biology questions seek development of higher order cognitive level.

4.2 Analysis of KCSE Biology question (2008-2018) in light of Bloom's cognitive domain with a view of establishing the extent to which they seek development of higher order cognitive level

The information in this section is organized in the following areas: a summary frequency of the cognitive domain KCSE Biology examination 2008-2018, frequency and mark allocation according to each KCSE Biology paper.

4.2.1 Cognitive level of KCSE Biology examination 2008-2018

Table 4.1 illustrates the distribution of nine hundred and forty-eight KCSE biology questions administered by the Kenya National Examinations Council (KNEC) according to the year of the examination and the cognitive skills (knowledge, comprehension, application, analysis, synthesis and evaluation) the questions were designed to measure

Table 4.1: Frequency of the cognitive level in KCSE Biology Examination 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% FREQ
KNOWLEDGE	44	35	43	45	36	34	37	30	45	38	26	413	43.57
COMPREHENSION	18	28	24	23	21	19	31	24	17	21	23	249	26.27
APPLICATION	18	11	10	11	16	14	11	13	15	23	23	165	17.41
ANALYSIS	9	12	10	8	8	9	12	11	11	12	14	116	12.24
SYNTHESIS	0	0	1	0	0	2	0	2	0	0	0	5	0.51
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	89	86	88	87	81	78	91	80	88	94	86	948	100.00

As seen in table 4.1 above, across the years the KCSE Biology examination cover mainly knowledge, comprehension and application levels of Bloom's taxonomy. The findings according to the table shows that Biology questions are mainly based on the lower order cognition levels of Bloom's taxonomy while a few questions are in higher order cognitive levels. However, across the years from 2008-2018, the year 2017 and 2018 shows change in setting of the exam, as major question in this year's cover mainly application, analysis and comprehension level. Knowledge level question are limited compared to other years.

Knowledge level with 43.57 %, required recall of names, terms, ideas and remembering of learned information. Comprehension questions of 26.27% dealt with understanding the meaning of concepts and ideas while application level with 17.41% used knowledge learned to solve problems in new situation; questions in this level further required students, to apply information, concepts and principles learned.

Most questions under higher-order cognitive level required analysis (12.24%). Synthesis level (0.53%) had the least number of questions. Analysis level questions entail breaking information, concepts, and ideas into parts so that learners can understand the ideas well. Synthesis domain on the other hand required learners to put the knowledge learned to form a new whole or new meaning. It involves creation. Evaluation level pertain to making judgments about values, theories, principles, and ideas.

Critical thinking, creativity, and problem-solving are crucial and of primary importance in 21st Century. These skills are only attained when objectives, instructional activities, and assessment measure all the categories of higher-order cognitive thinking. Educational objectives illustrate and describes what students are expected to learn; they are goals that serve to guide and give direction to educators on the learning process; they determine the behavior of the learners as evidence of learning outcome; they are tools that help curriculum implementers describe assessment techniques (Zulhelmi, 2018). Therefore, in order to educate, nurture holistic learners, and ensure appropriate curriculum coverage that leads to improved educational quality, teaching and assessment should be planned in a way that develops all the cognitive domains, with more emphasis on higher order objectives which should then be enhanced in our Kenyan school secondary curriculum.

Figure 4.1 shows the graphical representation and quick summary of the distribution of the KCSE Biology questions into the categories of the cognitive domain.

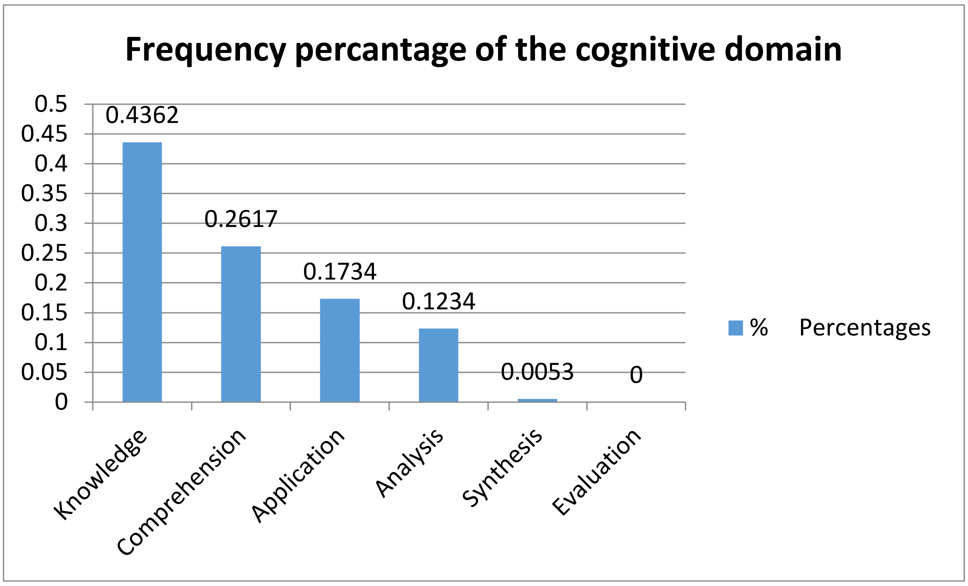

Figure 4.1 percentage frequency of Biology questions level.

An inspection of the shape of the bar chart shows that the frequency of the questions is not normally distributed among the six categories of the cognitive process skills across the examination years. For each year, majority of the questions are skewed to the left, where the questions require students to recall relevant biological knowledge from long-term memory and to construct meaning for biological concepts. Sivaraman and Krishna (2015) stated that questions should be designed such that knowledge and comprehension covers 20%- 30%, application and analysis 40% to 50% while synthesis and evaluation should cover between 30% and 40% of the set questions. However, the results from table 4.1 and figure 4.1 shows that the examination did not majorly tap on the higher-order cognitive domain this reveals that the educational goal of promoting retention and transfer of knowledge was not met. Anderson and Krathwohl (2001) emphasized that information and assessment should go beyond simple recall of knowledge as this enhances meaningful learning that aids learners with the knowledge and intellectual abilities for successful problem-solving.

4.2.2 Frequency and Mark allocation according to each Paper of KCSE Biology exam

KCSE biology examination is divided into three papers, and in order to clarify the issue in a detailed manner, this section presented tables of Bloom taxonomy levels with their frequencies regarding each biology paper during the period of 2008-2018. In addition, the mark allocated to each level was also examined.

KCSE Biology Paper 1

Paper I assess concepts across the secondary syllabus that is, composed of short answered questions which are all mandatory. The paper is marked out of 80.

Table 4.2: Frequency of the Cognitive Biology paper 1 exam 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% FREQ
KNOWLEDGE	31	21	25	30	22	22	21	18	28	22	13	253	52.71
COMPREHENSION	11	15	12	8	10	14	14	10	7	10	13	124	25.83
APPLICATION	6	4	1	4	5	2	4	5	6	9	9	55	11.46
ANALYSIS	4	6	5	3	4	3	5	5	2	5	4	46	9.58
SYNTHESIS	0	0	0	0	0	1	0	1	0	0	0	2	0.42
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	52	46	43	45	41	42	44	39	43	46	39	480	100.00

For paper 1 it is clearly understood from the table that 52.17% frequency are allocated to knowledge level, 25.83% to comprehension level, 11.46% to application level, 9.58% to analysis level and 0.42% to synthesis level. Evaluation domain question which required students to think scientifically was not asked in KCSE Biology paper 1. Therefore, knowledge level in lower-order thinking skills according to Bloom's Taxonomy rating higher than other levels within the same lower order, indicates that Paper I majorly tested on Knowledge of facts, principles, theories, and concepts of biology. Higher-order skills of applying knowledge and understanding of biology to new situations; inferring of biology principles and solving problems were not adequately assessed in the paper.

Sample of the cognitive level of 2016 KCSE Biology paper 1 include:

Knowledge: Name the type of muscle found in the stomach.

State three functions of blood other than transport.

Comprehension: Explain how protandry prevent self-pollination

Explain continental drift theory of evolution

Application: why is it not advisable to be in a poorly ventilated room with a burning charcoal stove?

Analysis: Distinguish between haemolysis and plasmolysis.

KCSE Biology paper 1 examination is worth 80 marks in total. Table 4.3 compares how the marks are distributed along each level of the cognitive domain.

Table 4.3: Mark allocated to each Level of Biology paper I 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% MARK
KNOWLEDGE	31	31	45	50	41	37	37	39	42	32	18	403	45.80
COMPREHENSION	20	31	24	18	17	29	27	25	15	22	33	261	29.66
APPLICATION	11	7	2	6	13	4	6	10	19	17	18	113	12.84
ANALYSIS	18	11	9	6	9	8	10	4	4	9	11	99	11.25
SYNTHESIS	0	0	0	0	0	2	0	2	0	0	0	4	0.45
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	80	80	80	80	80	80	80	80	80	80	80	880	100.00

Knowledge level in paper 1 has the highest percentage mark allocation of 45.80%, comprehension with a percentage of 29.66, application domain with 12.84%, analysis with 0.45% and synthesis domain with a percentage mark of 0.45. Comparing the years, 2018 has the lowest percentage of knowledge problem, major question in that year covered comprehension level. This implies that across the years, the trend of testing recall and regurgitation of information shifted. However, intellectual abilities of analyzing, synthesizing and evaluation of biological concepts still rated the lowest all through the years.

KCSE Biology paper II

This paper consists of two sections. Section A and section B. Section A, is a structured test worth 60 marks; the questions are sampled from 5 topics across the syllabus, each carrying 8 marks. All the questions here are compulsory. Section B on the other hand, comprise of question 6 which assess concepts on data manipulation and interpretation, carrying 20 marks. Question 7 and 8 consist of two essay questions worth 40 marks. Students choose one question in this category, bringing the total marks for this examination paper to 80 marks. Table 4.4 demonstrates the frequency of each level in the paper while table 4.5 reveals the mark distribution allocated to each category of Blooms' cognitive domain.

Table 4.4: Frequency of the Cognitive Biology paper II exam 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% FREQ
KNOWLEDGE	9	10	11	9	7	10	8	8	11	11	8	102	32.59
COMPREHENSION	6	10	9	13	9	4	11	12	5	6	6	91	29.07
APPLICATION	8	5	7	6	7	9	6	8	6	9	6	77	24.60
ANALYSIS	2	5	3	3	2	3	3	4	7	3	7	42	13.42
SYNTHESIS	0	0	1	0	0	0	0	0	0	0	0	1	0.32
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	25	30	31	31	25	26	28	32	29	29	27	313	100

From the results, the percentage frequency of lower order cognitive level rates higher compared to the higher-order cognitive level. Comprehension level has 29.07% frequency and the percentage mark allocated to it is 40%, the percentage frequency of the Knowledge level is 32.59% and the mark allocated to it is 20.34%. Application-level with 24.60% percentage frequency has 27.27%-mark allocation. The table further shows that analyze level carried the highest number of questions (13.42%) and mark allocation (12.16%) among the other categories of the HOCS (analysis, Synthesis, and evaluation).

Table 4.5: Mark Allocated to each level of Biology paper II 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% MARK
KNOWLEDGE	17	14	18	16	12	20	18	14	16	17	17	179	20.34
COMPREHENSION	28	28	35	41	38	21	43	33	28	29	28	352	40.00
APPLICATION	32	19	19	18	21	26	15	19	24	27	20	240	27.27
ANALYSIS	3	19	6	5	9	13	4	14	12	7	15	107	12.16
SYNTHESIS	0	0	2	0	0	0	0	0	0	0	0	2	0.23
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	80	80	80	80	80	80	80	80	80	80	80	880	100.00

The results from table 4.4 and table 4.5 shows that KCSE biology paper II, mainly expect students to demonstrate an understanding of biological facts by: describing concepts and ideas, giving explanations supported by evidence and justification (essay question) or summarizing biological knowledge and giving relevant examples (example of a question from KCSE 2018 is: describe the adaptation of the eye to its function).

Applying learned material in a new situation through solving calculation (work out the genotypic ratio of the offspring, KCSE Biology 2018) and drawing graphs (question 6, which is a compulsory question to all the students) is a domain frequently examined in Biology paper II, however, putting biological information together into a new whole(synthesis) only comprised one question of the year 2010 (construct two food chain with lizards as a tertiary consumer). Evaluation domain of judging the value of biological phenomena and ideas is hardly tested across the years.

KCSE Biology paper III

It's a practical paper that consists of three structured questions that carry 40 marks. The three questions are drawn from any three topics within the syllabus. All the questions are mandatory. The following tables below (4.6 and 4.7) depict the frequency of each level and mark allocation respectively.

Table 4.6: Frequency of the Cognitive Biology paper III exam 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% FREQ
KNOWLEDGE	4	4	7	6	7	2	8	4	6	5	5	58	37.42
COMPREHENSION	1	3	3	2	2	1	6	2	5	5	4	34	21.94
APPLICATION	4	2	2	1	4	3	1	0	3	5	8	33	21.29
ANALYSIS	3	1	2	2	2	3	4	2	2	4	3	28	18.06
SYNTHESIS	0	0	0	0	0	1	0	1	0	0	0	2	1.29
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	12	10	14	11	15	10	19	9	16	19	20	155	100.00

For paper III Knowledge level had a frequency of 37.42%, comprehension level 21.94%, application level 21.29%, analysis level 18.06% and synthesis domain 1.29%. Evaluation level was not tested in the paper.

2015 sample KCSE Biology question of paper three is as shown below:

Knowledge: Name the bone covered by the fatty tissue

Comprehension: Explain the role of the part labelled in inhalation

Application: Calculate the magnification of the image

Analysis: How are the parts labelled S and V adapted to their functions?

Synthesis: construct the dichotomous key that can be used to identify the specimen

Table 4.7: Mark Allocated to each Level of Biology paper III 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% MARK
KNOWLEDGE	8	11	23	18	11	3	12	11	9	6	7	119	27.05
COMPREHENSION	11	9	5	5	5	5	15	4	18	8	10	95	21.59
APPLICATION	16	8	4	3	20	0	3	0	9	15	19	97	22.05
ANALYSIS	5	12	8	14	4	20	10	12	4	11	4	104	23.64
SYNTHESIS	0	0	0	0	0	12	0	13	0	0	0	25	5.68
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	40	40	40	40	40	40	40	40	40	40	40	440	100.00

For paper III the mark allocation according to each domain as seen from the table is: knowledge level 27.05%, comprehension with 21.59%, application level with 22.05% and analysis domain with 23.64%. Higher-order synthesis level was the least tested with 5.68%-mark allocation. No biology question tested on the evaluation domain. This clarifies that creativity and critical reasoning are lacking in Kenya's national biology examination.

4.2.3 Summary of KCSE Biology mark allocation in the period 2008-2018 at various levels of the cognitive domain

After analyzing the marks allocated to the 2008-2018 KCSE Biology examination paper using operational verbs in Bloom's taxonomy table, the following results were obtained.

Table 4.8: Summary of KCSE Biology mark allocation 2008-2018

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTAL	% MARK
KNOWLEDGE	56	56	86	84	64	60	67	64	67	55	42	701	31.87
COMPREHENSION	59	68	64	64	60	55	85	62	61	59	71	708	32.18
APPLICATION	59	34	25	27	54	30	24	29	52	59	57	450	20.45
ANALYSIS	26	42	23	25	22	41	24	30	20	27	30	310	14.09
SYNTHESIS	0	0	2	0	0	14	0	15	0	0	0	31	1.41
EVALUATION	0	0	0	0	0	0	0	0	0	0	0	0	0.00
TOTAL	200	200	200	200	200	200	200	200	200	200	200	2200	100.00

The results show that Comprehension level with 32.18 % was allotted a high percentage mark, followed by the knowledge level with 31.86%, application-level with 20.45%, analysis with 14.09%, synthesis with 1.41% and evaluation level with no percentage mark.

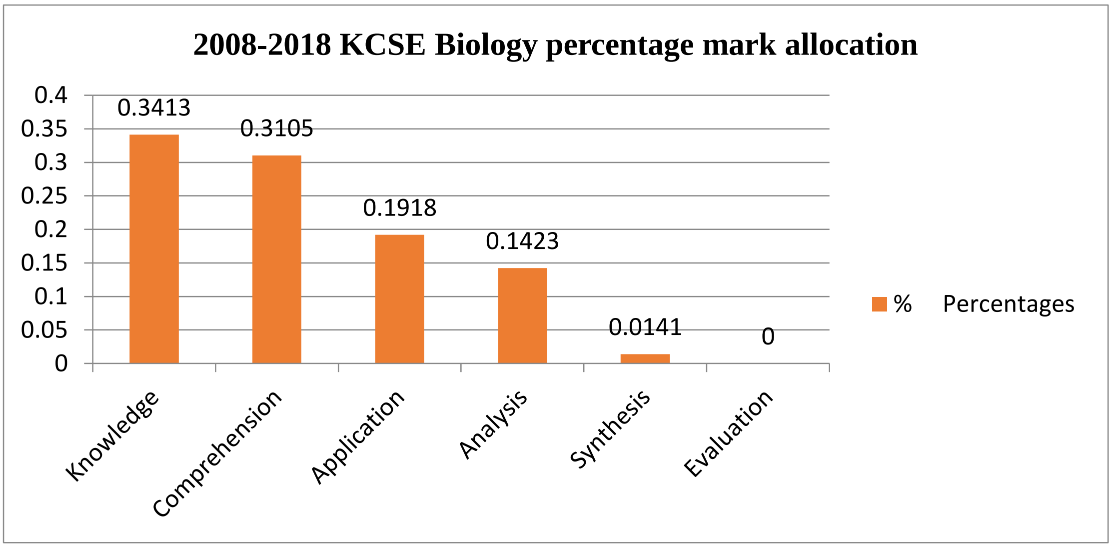

Figure 4.2: Percentage mark allocation of the Six Level of KCSE Biology 2008-2018.

According to KNEC reports 2008-2018, most questions students failed to answer are the ones that required the learners to apply knowledge." KNEC Report 2013" pointed out that, across all the three papers the questions involving application of biological knowledge and biological processes were poorly performed compared to those that required factual knowledge.

"KNEC Report 2017" equally observed that, the questions that required an extra effort to comprehend, interpret, infer (from a diagram, photograph, a process and data) were poorly performed unlike the straight-forward ones. One of the recommendations therefore given by the 2008-2018 KNEC reports was that, "All topics and activities should be given equal attention during the teaching and learning as opposed to selective approach out of predictions for examinations purposes".

4.3 Discussion of the Findings

For the whole units, it is clearly understood from table 4.1(frequency of the cognitive level) and table 4.8 (summary of the mark allocation) that knowledge level is more dominant in KCSE Biology questions, with 31.87 percentage mark allocation and a frequency of 43.62%. Comprehension levels follows with 32.18%-mark allocation and 26.27% frequency. The application-level was less common than comprehension and knowledge level in Lower Order Cognitive Skill, it constituted 20.45%-mark allocation and a frequency of 17.41%. Analysis level followed the application level with a percentage of 14.09%-mark allocation and a frequency of 12.24%. The synthesis domain was the least common as it constituted only 1.41%-mark allocation and a frequency of 0.51% of the exam questions. No question tested on evaluation. This shows that KCSE Biology examination is not challenging enough to warrant critical thinking among learners. The findings and results are consistent with school-based assessments discussed in the literature (Karamustafaoglu, Sevim, Karamustafaoglu & Cenci 2003; Azar, 2005; Tsaparlis & Zoller, 2003; Zheng, Lawhorn & Freeman, 2008).

Evaluation and Synthesis are the two levels predominantly not assessed in KCSE Biology examination yet the ability to use reasoned judgment and critical thinking is a hallmark of education. Brookhart (2010) asserts that instruction and assessment should match the intended learning outcome in both contents (what the student learns) and mental complexity (what the learner is able to do with the learning). When students solve new problems or do original thinking with their knowledge, they transfer what they learned, and their understanding thrives (Case, 2013). This higher cognitive level similarly increases students' sense of control over ideas as students become engaged in thinking, leading to increased motivation as well as achievement in their standardized test scores, classroom grades and research instruments (OECD, 2013).

Burdett (2017) acknowledges that, as the world becomes increasingly technological it is crucial that all students acquire a basic understanding of the science and technology that surrounds them, and can understand the debates that influence them in an informed way. Learning a lot of dissociated scientific facts is not the same as being scientifically literate. The outcomes and actions of future citizens need to be based on an awareness and understanding of their world and on the ability to ask relevant questions, seek answers, define problems and find solutions (Wagner, 2008). Thus, the main focus of assessment should be on evaluating skills and concepts, instead of knowledge. However, the findings from KCSE Biology reveal that there is a huge gap between what is being examined and the skills and knowledge needed by learners leaving school. A lot of emphasis is on scientific knowledge, but scientific literacy and the skill to evaluate scientific statements or make informed decisions is lacking.

According to NESP (2015) report, the overarching goal of Kenya's Ministry of Education is; enhanced quality basic education for Kenya's sustainable development, this is mainly through enhancing the quality of all aspects of education and training so that accepted and measurable learning outcomes are attained, primarily in literacy, numeracy, and basic life-skills relevant to the world of work and social competencies and values. However, from the research finding of KCSE Biology 2008-2018, the goal of higher cognitive domain has not yet been achieved. The Education goal policy of reforming national assessment and examinations to assess skills, competencies, curricula, and values should be given prominence to.

4.4 Summary of Chapter Four

From the research findings, KCSE Biology examination is adequately distributed along the lower-order cognitive level, however, majority of the questions under higher-order cognitive level required analysis. Synthesis had the least number of questions while evaluation domain was not tested in all the examination papers**.** This means that the skill of innovation, making valued decision and judgement is not adequately instilled in the assessment.

Knowledge and skills taught serve no meaning if it cannot be used in new situations or in a form different from that it was originally encountered (higher order skills). Anderson, 2001 stated that simple acquisition of knowledge is only important for passing exams, Bloom (1956) further suggested that students should also be taught to apply the knowledge along with higher-order thinking skills as this is the most effective method for establishing meaningful lifelong learning.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the findings of the outcome of a research exercise on KCSE Biology examination through Bloom's taxonomy to bring out conclusions. The summary gives an objective view and a thoroughly thought process with concrete recommendations for adoption by education stakeholders. It further points out on the next course of action including monitoring and evaluation to cement on the findings and how to enrich future undertaking.

5.2 Summary of the Study

The goal of this study aimed at analyzing the KCSE Biology examination questions from 2008 to 2018. The approach maximized on Blooms' Cognitive domain theory. Special emphasis zeroed on the analysis of the contents of KCSE Biology Examination with a view of determining the extent at which it seek development of higher order cognitive skills. Document analysis was employed in data collection. Mixed method approach was used to authenticate the accuracy of the data collected.

5.3 Summary of the Finding

5.3.1 To analyse the KCSE Biology question (2008-2018) in light of Bloom's cognitive domain

Drawing from the findings, Knowledge level constituted 43.57%, comprehension questions 26.27%, application level 17.41%, analysis level 12.24%, Synthesis level 0.53% and evaluation level with 0%. Meaning, a lot of emphasis of the examination is on; evaluating large amounts of facts pertaining to biological knowledge but much less on the ability of the learners to think scientifically or apply biological knowledge in a beneficial way. This implies that there is a lot of emphasis by examiners on the larger scope of exam passing as opposed to the need to challenge critical thinking and problem solving skills. The research further points out a weak link between what is taught and what is examined. On one hand, the curriculum as stated in the Biology secondary syllabus (KICD, 2018) boasts of a robust teaching methodologies but in the end, fails to structure questions accordingly to meet the teaching objectives and market demand. These findings, therefore signify the need to increase the number of higher-level examinable questions on every KCSE biology tests and examination.

5.3.2 To determine the extent to which KCSE Biology question seek development of higher order cognitive skills

The lower level of Bloom's taxonomy cognitive domain that is (knowledge, comprehension, and application) constituted the highest percentage. Analytically, the research gathered a convincing evidence of 87.25% frequency and 84.50%-mark allocation. This is in comparison to the higher cognitive levels that entails (analysis, synthesis, and evaluation) which recorded lower percentage frequencies of 12.24%, 0.51%, and 0%. Similarly, mark allocation posted 14.09%, 1.41%, and 0% respectively.

Higher-order thinking means students can reason, reflect, and make sound decisions on their own without prompting from teachers. These skills are problem-solving and critical thinking facet of scientific methodology which are worthy objectives of science education (Wagne, 2008). They are the 21st-century skills that comprise analysis, synthesis and evaluation domain. Anderson and Krathwohl, (2001) stated that, the most important educational goals are to promote retention and transfer for meaningful learning. Retention requires that students remember what they have learned (lower order levels) in their learning. Whereas transfer which falls under higher-order cognitive level requires students not only to recall but also make sense of and be able to use what they have learned.

The general main objectives of teaching Biology in secondary school as indicated by KICD (2018) is for students to: cultivate knowledge, conceptual awareness and abilities to solve problems and make the informed decisions in scientific and other contexts; develop skills of scientific inquiry to construct and carry out a scientific investigation, evaluate scientific evidence in order to draw conclusions; communicate scientific ideas, arguments and practical experiences accurately in a diversity of ways; think analytically, critically and creatively to solve problems, judge arguments and make decisions in scientific and other contexts.

These innovative approaches therefore need to be equally incorporated in the secondary education biology assessment in order to enable learners cope with the dynamics of the 21st century. The examination should provide for various competencies, abilities and interest learners need in diverse contexts. This is a key step in transformation of the country into a knowledge economy as envisioned in the Kenya Vision 2030 and Constitution of Kenya (2010).

5.4 Conclusion of the Study

From the research finding, the researcher presents the following conclusion according to the following study objective: To analyse the KCSE Biology question (2008-2018) in light of Bloom's cognitive domain. To determine the extent to which KCSE Biology question seek development of higher order cognitive skills.

5.4.1 To analyze the KCSE Biology question (2008-2018) in light of Bloom's cognitive domain

An overview of the research findings brings to the reality the following issues: The lower order of Bloom's taxonomy cognitive domain has taken a sizeable proportion of Biology examination questions administered to students during the Kenya Certificate of Secondary Education from 2008 – 2018. The higher order cognitive level of biology Kenya Certificate of Secondary Education from 2008 to 2018 is negligible. The Kenya National Examination Council has not adequately, examined students sitting for Biology subject on aspects of critical thinking and innovation which is key in addressing the missing gaps in our society.

The percentage of the KCSE Biology questions that required Lower Order Cognitive Skill is very large with 87.25% frequency. This is consistent with school-based assessments discussed in the literature (Karamustafaoglu, Sevim, Karamustafaoglu & Cenci 2003; Azar, 2005; Tsaparlis & Zoller, 2003; Zheng, Lawhorn & Freeman, 2008). Going by the results of this research, the researcher concluded that the biology examination questions in Kenya conducted by Kenya National Examination Council is not as adequately demanding tasks as they should be.

5.4.2 To determine the extent to which KCSE Biology question seek development of higher order cognitive skills

From the analysis, there was less implementation of higher order cognitive questions, this deprives students from concrete thinking, problem solving, decision making and their logical abilities get wasted. The secondary school curriculum states the objectives using measurable verbs according to all levels of cognitive domain. Consequently, it would be expected that examination, which are meant to find out whether the objectives are met, should also be in measurable form by use of action verbs. Examiners should ensure that the 21st century skills are acquired by learners by setting questions that move up the levels of Bloom's Taxonomy. Students become critical thinkers by letting them apply, analyze, synthesize and evaluate facts, ideas and theories.

Emphasis in learning and examination should be in larger understandings with analysis, synthesis and evaluation going on simultaneously. Reflective thinking in where both induction and deduction should be utilized. Factual information, drill, and memorization should be subordinated for more significant goals. Thus, KCSE Examination should provide evidence of the science concepts developed in the course rather than simply the acquisition of factual knowledge.

5.5 Recommendation

In outlining the next course of action, the research is proposing the following measures if we are to move our education from theoretical to skills driven and innovation.

i. Higher order cognitive skills that fosters orientation, concept strategies and assessment methodologies should be embraced as teaching focus in schools.
ii. Examination body (Kenya National Examination Council-KNEC) should ensure that Biology examination questions reflect the perspective of the Bloom's taxonomy of higher level of cognitive thinking of *analyzing, synthesizing and evaluating*
iii. Summative assessment such as the KCSE Biology questions should be sufficiently challenging, and suitable for preparing students for entry into higher Levels (university) biology learning.

5.6 Suggestion for Further Research Studies

To further enrich the findings, the research is suggesting the following:

i. Since the research study was conducted with particular emphasis on KCSE Biology, similar research study in other subjects including and not limited to sciences, languages, technical and humanities should be undertaken.
ii. Future studies should be approached with other domains of bloom taxonomy as a way of finding out the balance and threshold of researches.

iii. A comparative overview of question in high school textbook with questions presented to the students in the KCSE Biology exams should too be evaluated.

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APPENDICES

Appendix I: Examples and Analysis of Questions

Exam questions can be included into each of the six classifications of Bloom Taxonomy' during analysis of the questions, the following criteria will be used.

1. Knowledge. Questions on the knowledge level require the students to remember facts they have already learned and recall these as they have been learned.

Question: Define the term Taxonomy?

2. Comprehension. Students must be able to rephrase information, using their own statements and translate knowledge into new context and interpret graphs, tables and charts

Question: We use fossil fuels in the various fields in our daily life. Discuss the impacts, using fossil fuels, on society and on the environment.

3**. Application.** Students are required to identify the relevant information and rules to arrive at a solution and solve problems by using known algorithms.

Question: Feather color in budgies is determined by two different genes (Y and B). Y_B_, is

Green; yyB_ is blue; Y_bb is yellow; and yybb is white. Two green budgies were crossed. Over the years, they produced 22 offspring, 5 of which were white.

· What are the most likely genotypes for the two green budgies?

· Determine the probability that an offspring will be recessive for at least one trait. (Assume these genes are unlinked and autosomal.)

4. Analysis. The analysis level requires that students separate an idea into its parts or elements and demonstrate an understanding of the relationship of the parts to the whole.

Question: Compare and contrast the equation for oxidative respiration with the equation for Photosynthesis.

5. Synthesis. Questions on synthesis level permit students to devise ways to design experiments and test hypotheses. Students may be required to write a paper and a report in which ideas are synthesized or problems are solved.

Question: What would happen if the animal cells also had the organelles that ar not in animal cells but in plant cells?

6. Evaluation. Questions at this level require students to make judgments about the value or merit of an idea, purpose and solution to a problem, procedure, method or product. This level requires students to use the other five levels of the taxonomy to varying degrees.

Question: Judge the benefits of meiosis and mitosis for our life.

Appendix II: Bloom Taxonomy Checklist

NO	QUESTION	KNOWLEDGE	COMPREHENSION	APPLICATION	ANALYSIS	SYNTHESIS	EVALUATION	MARKS
MARKS								

Cognitive level	Paper I	Paper II	Paper III	MARKS
KNOWLEDGE				
COMPREHENSION				
APPLICATION				
ANALYSIS				
SYNTHESIS				
EVALUATION				
MARKS				

NO	QUESTION	KNOWLEDGE	COMPREHENSION	APPLICATION	ANALYSIS	SYNTHESIS	EVALUATION	MARKS
1	(a) Name the cell organelle found in abundance in the white blood cells.							1 mark
	(b) Give a reason for your answer in (a) above.							1 mark
2	State two observable features that place a millipede into its Class.							2 marks
3	Which sets of teeth would be used in chewing sugarcane for maximum extraction of sap?							2marks
4	A group of form two students placed a fresh leaf in warm water. They observed that air bubbles formed on the surface of the leaf. (a) What biological process were they investigating?							1 mark
	(b) Name the structures from which the air bubbles were coming from.							1 mark
	(c) Explain the distribution of the structures named in (b) above on the leaf surfaces of a land plant.							2 marks
5	State why it is important for plants to lose water to the atmosphere.							3 marks
6	The diagram below illustrates tissue fluid and cells surrounding a capillary. (i) Name fluid G.							1 mark
	(ii) Give two ways by which fluid G is different from tissue fluid.							2 marks

7	. (a) Define respiration.							1 mark
	(b) State three activities in the human digestive system that depend on respiration.							3 mark
8	State three ways in which blood capillaries are structurally adapted to their functions							3 marks
9	The diagram below represents an organ in a bony fish. (a) Name the organ.							1 mark
	(b) Describe how air in water reach the capillaries inside structure L.							3 marks
10	Name two products of respiration in plants.							2 marks
11	(a) State one homeostatic role of the human skin.							1 mark
	(b) Name three structures of the skin essential for its homeostatic function.							3 marks
12	Explain why the nephron is long and convoluted.							3 marks
13	State two limitations of using a quadrat to estimate the population of organisms.							2marks
14	The diagram below illustrates a germinating seedling. (a) Name the type of germination illustrated in the diagram.							1 mark
	(b) Describe how the type of germination named in (a) above is brought about.							3 marks

15	Explain why a bony fish dies shortly after being removed from water.							4 marks
16	Name the bones that articulate to form a ball and socket joint at the hip.							2 marks
17	Explain the role of carbonic anhydrase in red blood cells.							4marks
18	A tall, light skinned lady with pimples on her face has long hair and limps. (a) List two features which the lady has that are due to inheritance.							2 marks
	(b) Explain why most recessive genes are expressed phenotypically in male offspring of humans.							3 marks
19	The diagrams below illustrate some forms of beaks in birds. (a) Which diagram represents the beak from which the others are likely to have evolved?							1 mark
	(b) Explain your answer in (a) above.							3 marks
20	(a) Define the term analogous structures.							1 mark
	(b) Give two illustrations of analogous structures in mammals.							2marks
21	State two ways in which plants with weak stems obtain mechanical support.							2 marks
22	What does the term evolution mean?							1 mark

23	State two characteristics of living things illustrated in the photograph below.							2 marks
24	Explain why a camel has a longer nephron than a whale.							1 mark
25	Desert kangaroo rats spend most of their time in underground burrows. (a) Name this type of behavioral activity							1 mark
	(h) Explain the significance of this behavior to the organism.							3 marks
26	State two advantages terrestrial animals have in excreting urea as their main nitrogenous waste product.							2marks
27	Below is a graphical representation of how basal metabolic rates compare in various animals. From the graph explain why the mouse has a higher breathing rate than the elephant.							4 marks
TOTAL MARKS								

Appendix III: Letter from the University

MOI UNIVERSITY
Office of the Dean School of Education

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P.O. Box 3900
Eldoret, Kenya

An ISO 9001: 2008 CERTIFIED INSTITUTION

REF: EDU/PGCM/1051/16 **DATE:** 27th May , 2019

The Executive Secretary
National Council for Science and Technology
P.O. Box 30623-00100
NAIROBI

Dear Sir/Madam,

RE: RESEARCH PERMIT IN RESPECT OF YATOR FAITH JEPTOO – (EDU/PGCM/1051/16

The above named is a 2nd year Master of Education (M.Ed) student at Moi University, School of Education, Department of Curriculum , Instruction and Educational Media.

It is a requirement of her M.Ed Studies that she conducts research and produce a thesis. Her research is entitled:

"Distribution of Examination Questions along Bloom Taxonomy: An Analysis of KCSE Biology Exam in Kenya: 2010-2018."

Any assistance given to enable her conduct research successfully will be highly appreciated.

Yours faithfully,

27.5.2019.

PROF. J. K. CHANG'ACH
DEAN, SCHOOL OF EDUCATION

(ISO Certified Institution)

Appendix IV: Research Permit

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

National Commission for Science, Technology and innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 25606

CONDITIONS: see back page

THIS IS TO CERTIFY THAT:
MS. FAITH JEPTOO YATOR
of MOI UNIVERSITY, 0-30100
ELDORET,has been permitted to conduct research in Uasin-Gishu County

on the topic: DISTRIBUTION OF EXAMINATION QUESTIONS ALONG BLOOM TAXONOMY;AN ANALYSIS OF KCSE BIOLOGY EXAM IN KENYA: 2010-2018

for the period ending:
24th June,2020

Permit No : NACOSTI/P/19/49306/31133
Date Of Issue : 27th June,2019
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix V: Research Authorization NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471,
2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/49306/31133**

Date: **27th June 2019**

Faith Jeptoo Yator
Moi University
P.O Box 3900-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Distribution of examination questions along bloom taxonomy: An analysis of KCSE biology exam in Kenya: 2010-2018."*** I am pleased to inform you that you have been authorized to undertake research in **Uasin Gishu County** for the period ending **24th June, 2020.**

You are advised to report to **the County Commissioner, and the County Director of Education, Uasin Gishu County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

DR. ROY B. MUGIIRA, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Uasin Gishu County.

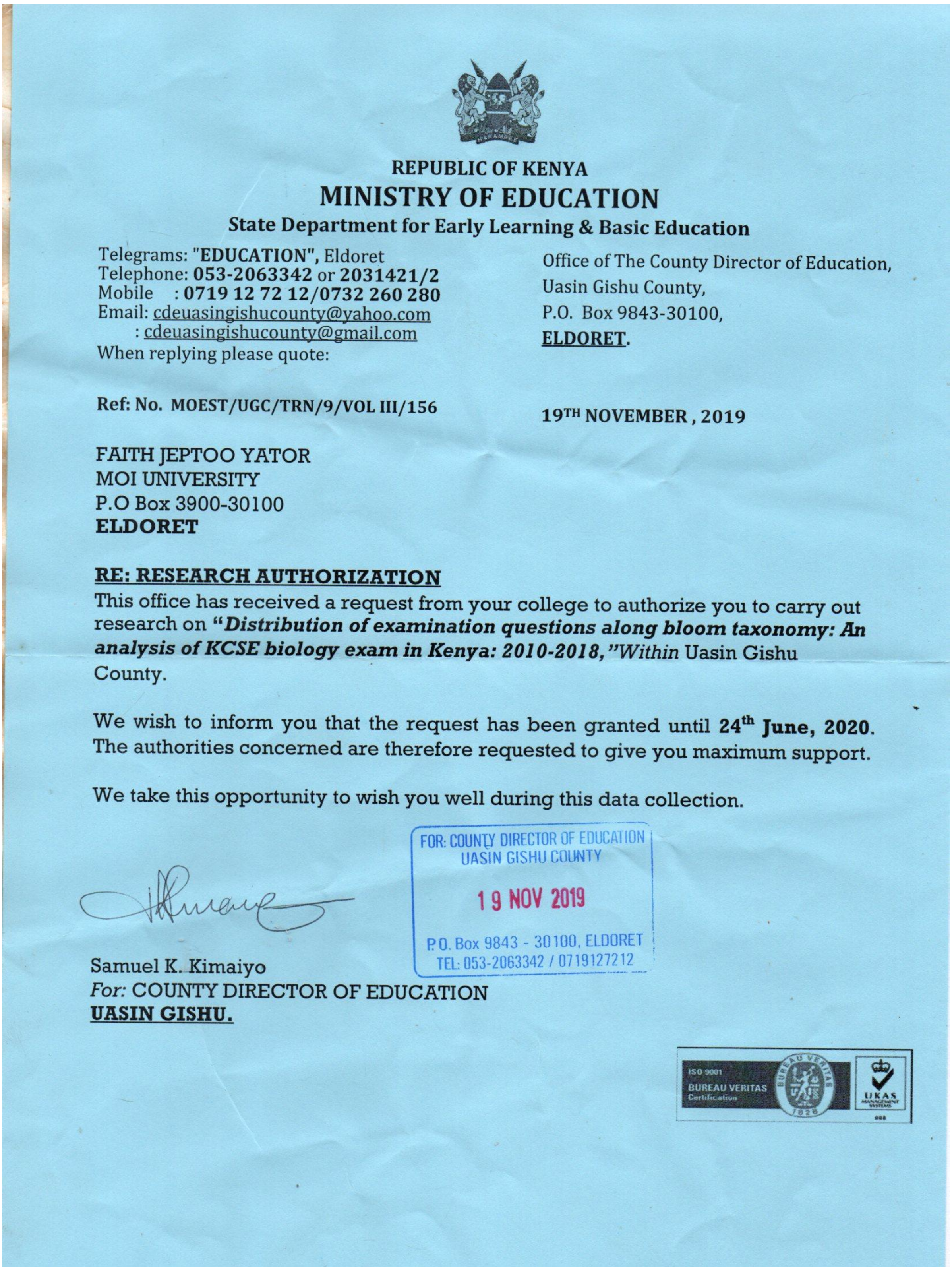
The County Director of Education
Uasin Gishu County.

COUNTY COMMISSIONER
UASIN GISHU COUNTY

Proceed
19/11/19

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

Appendix VI: Research Authorization; Ministry of Education



REPUBLIC OF KENYA
MINISTRY OF EDUCATION
State Department for Early Learning & Basic Education

Telegrams: "EDUCATION", Eldoret
Telephone: 053-2063342 or 2031421/2
Mobile : 0719 12 72 12/0732 260 280
Email: cdeuasingishucounty@yahoo.com
: cdeuasingishucounty@gmail.com
When replying please quote:

Office of The County Director of Education,
Uasin Gishu County,
P.O. Box 9843-30100,
ELDORET.

Ref: No. MOEST/UGC/TRN/9/VOL III/156

19TH NOVEMBER, 2019

FAITH JEPTOO YATOR
MOI UNIVERSITY
P.O Box 3900-30100
ELDORET

RE: RESEARCH AUTHORIZATION

This office has received a request from your college to authorize you to carry out research on "***Distribution of examination questions along bloom taxonomy: An analysis of KCSE biology exam in Kenya: 2010-2018,***"*Within* Uasin Gishu County.

We wish to inform you that the request has been granted until **24th June, 2020.** The authorities concerned are therefore requested to give you maximum support.

We take this opportunity to wish you well during this data collection.

FOR: COUNTY DIRECTOR OF EDUCATION
UASIN GISHU COUNTY
19 NOV 2019
P.O. Box 9843 - 30100, ELDORET
TEL: 053-2063342 / 0719127212

Samuel K. Kimaiyo
For: COUNTY DIRECTOR OF EDUCATION
UASIN GISHU.

ISO 9001
BUREAU VERITAS
Certification
UKAS