INFLUENCE OF UTILISATION AND DESIGN OF CURRICULUM DIGITAL CONTENT ON BIOLOGY INSTRUCTIONAL PROCESS AMONG SECONDARY SCHOOLS IN NAIROBI COUNTY, KENYA

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NOVEMBER, 2016

DECLARATION

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

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DEDICATION

This work is dedicated to all the proponents of e-learning and everyone who has supported curriculum digital content design, development, dissemination and utilisation.

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ABBREVIATIONS AND ACRONYMS

ACTF	Australian Children's Television Foundation
CAI	Computer Assisted Instruction
CD	Compact Disk
CDE	County Director of Education
DEO	District Education Officer
DVD	Digital Versatile Disk or Digital Video Disk
EFA	Education for All
ESP	Economic Stimulus Programme
FPE	Free Primary Education
GUI	Graphical User Interface
ICT	Information Communication Technology
JICA	Japan International Cooperation Agency
KCSE	Kenya Certificate of Secondary Education
KEMI	Kenya Education Management Institute
KICD	Kenya Institute of Curriculum Development
KIE	Kenya Institute of Education
KNEC	Kenya National Examinations Council
MoE	Ministry of Education
MoIC	Ministry of Information and Communication
MPEG	Motion Picture Experts Group
NACICTIE	National Centre for ICT Integration in Education
NACOSTI	National Commission for Science, Technology and Innovation

NDLRN	National Digital Learning Resources Network
NEPAD	New Partnerships for Africa's Development
PDF	Portable Document Format
PTR	Pupil Teacher Ratio
SAGA	Semi-Autonomous Government Agencies
SREB	Southern Region Education Board
UI	User Interface
UNESCO	United Nations Educational, Scientific and Cultural Organization
URL	Uniform Resource Locator
VDS	Vision 2030 Delivery Secretariat

ABSTRACT

The quality of curriculum and curriculum support materials used by the teachers and learners affects the quality of education that is delivered during an instructional process. For many years, educational materials have mostly been static text with pictures printed in books. These kinds of materials do not have strong potential to provide appropriate learning environment for learners who are technologically savvy and who expect interactive engaging learning experiences. In recent years, there has been rapid expansion in digital content development and access in schools. There have been many initiatives geared towards development and provision of digital content to schools in Kenya. However, little has been done to ensure that learners and teachers actually utilize the digital content in the instructional process. This study therefore investigated the influence of utilisation and design of curriculum digital content on Biology instructional process among secondary schools in Nairobi county, Kenya. It also sought to provide a model for development of effective digital content for Biology instruction. It was guided by five specific objectives. These include to; establish secondary school learners' and teachers' utilisation of curriculum digital content in the Biology instructional process, determine whether utilisation of secondary school curriculum digital content influences the Biology instructional process, analyse the nature, and influence of curriculum digital content multimedia elements on the secondary school Biology instructional process, examine the formulation, and influence of curriculum digital content user interface on the secondary school Biology instructional process and derive a model that can guide the design and development of an effective digital content for secondary school Biology curriculum. A mixed methods design was used for the study which involved fifteen ESP-ICT phase 1 secondary schools and two digital content development institutions in Nairobi county. Six instruments were used for data collection which include; Biology teacher questionnaire, learners' focus group discussion guide, Biology teaching and learning resources inventory, digital content analysis sheet, documents analysis sheet and digital content developers' interview schedule. The collected data was analysed using both descriptive and inferential statistics and presented in form of notes, numerals, tables, and graphics. This study found out that utilisation of curriculum digital content influenced assessment and achievement of learners in Biology positively. However, the study found no significant difference in syllabus coverage between the groups that utilised Biology digital content and the ones that did not. There were also issues in Biology digital content access, multimedia elements and user interface which affected content utilisation and consequently its influence on the instruction process. Packaging and dissemination of digital content in both online and offline formats was recommended to improve the level of access and utilisation of digital content. To address the design issues of the content, the study recommended that developers do proper needs analysis, proper combination of multimedia elements and design appropriate user interfaces. The study also derived a model that can guide and improve the process of developing more effective curriculum digital content.

CHAPTER ONE

INTRODUCTION

1.1 Preamble

This chapter is mostly engrossed on the introduction of this study. It provides the background information, statement of the problem, study objectives and research questions. In addition, the chapter gives the significance of the study, scope and limitations, basic assumptions and the theoretical framework of this study. The conceptual framework and definition of terms are also provided in this chapter.

1.2 Background information

Biology is the science of life and living organisms, including their formation, development, function, origin, evolution, taxonomy and distribution (Free online dictionary, 2013). Biology is a vast subject encompassing many units, topics, and disciplines. Among the most important topics are five uniting principles which are the fundamental maxims of modern Biology (Vernon, 1995). These principles focus on the cell, respiration, homeostasis, heredity and evolution. The field of Biology deals with the study of living things and how they relate to each other and with their environment (Maundu, Sambili and Mutwii, 2005)

Biology is one of the science subjects that are offered at the secondary school education cycle in Kenya (KIE, 2002). According to Maundu et al (2005), biological information has by and large, been used to improve the welfare of humankind. The knowledge in Biology contributes to scientific literacy so that people can appreciate the world around them and enable them to make well-informed choices about their healthcare, their environment and the society in which they live (Karen, 2008). As outlined by KIE (2002), the study of Biology aims at equipping the learner with knowledge, skills, and attitudes that are necessary for controlling and preserving the environment; enables the learner to appreciate humans and as part of the broader community of living organisms; is a foundation for careers in health, agriculture, environment and education; and is the precursor of biotechnology which is a tool for industrial and technological development.

Despite the significance of the knowledge of Biology, learners' achievement in this subject at Kenya Certificate of Secondary Education (KCSE), which is offered by the Kenya National Examinations Council (KNEC), has been low over the years (MoE, 2005; Muraya and Kimamo 2011). This does not auger well for Education for All (EFA) which adopted learning achievement as a key indicator of the quality of education during the World Conference on Education for All in Jomtien, Thailand, (UNESCO, 2000).

Many factors contribute to low scores in science at KCSE. These factors include: student attitude towards the subjects which they perceive as difficult, inappropriate teaching approaches that are teacher centered rather than learner centred, inadequate mastery of teaching subject content by some teachers, inadequate teaching and learning resources, poor terms and conditions of service for teachers and heavy teaching loads (Kibe, JICA-Kenya in Muraya and Kimamo, 2011). Nyaga (2011) noted that the instructional methods used by teachers determine the performance of learners to a great extent. Adeyemi, (2008) argues that the lecture method, which is predominant in our classrooms, does not inspire innovations, inquiry and scientific thinking but rather encourages students to memorise facts which are easily forgotten. Kolawole (2008) observed that teacher centred teaching approaches are dominant at the secondary school level where the teacher presents information to learners' in a lecture and students complete assignments out of the class and later take examinations to exhibit their degree of understanding and retention of subject matter.

In order to address the low achievement in Biology at KCSE in Kenya, Biology teachers need to be exposed to appropriate teaching and learning approaches that are learner centered (Muraya and Kimamo, 2011). For effective teaching and learning to occur, the teacher must use an effective approach of conveying the information to the learner (Brown, Oke and Brown, 1992). The learner centered teaching and learning approaches actively engage the learner in the learning process for effective mastery of the subject content matter and promotes a positive attitude towards the subject (Ministry of Education Science and Technology, 2011).

Coverage of the set content is another factor that can improve the achievement of learners in examinations. A positive relationship exists between syllabus coverage and performance at national examinations (Amadalo, Shikuku and Wasike, 2012). According to KNEC (2011), teachers should cover the syllabus adequately to enable students to have a clear grasp of the content. There are ten subject objectives that need to be achieved and seventeen topics that should be covered in secondary school Biology in Kenya (KIE, 2002).

Collaboration has been identified as an important way of acquiring subject content (Centre for Digital Education, 2010). The Centre for Digital Education (2010) posits that modern education environments require a new model that engages learners who are technologically savvy and who expect interactive experiences and desire to learn collaboratively. KNEC (2011) noted that schools should use e-learning to enable leaners access diversified content for easy understanding of science concepts. Digital content is one of the important curriculum support materials that can be used to improve the quality of education, increase access and eventually ensure equity in education. It offers the suppleness to make learning learner cantered and an enduring endeavour that can promptly convey reliable and engaging learning experiences. It is malleable, enabling teachers and learners to more easily utilise, manipulate and control information to address specific learning objectives and to better match individual learning styles. Digital content delivery promises more effective, cheaper and more personalised educational materials.

It is difficult to give a particularly suitable definition of digital content (Centre for Digital Education 2010). However, in the education context, digital content refers to all materials or programs stored on an electronic or digital medium that can be transmitted or utilised through computers, over networks and the Internet. Digital Content is any content that can be consumed from an electronic device such as personal computer, mobile devices or digital television (Kenya ICT Board, 2011). It comprises of text, images, sounds, animations, games and videos that have been digitised, or brought into a computer. By virtue of one vital feature, flexibility, digital media surpasses traditional media in their ability to meet diverse learners' desires in a variety of instructional contexts. With digital content and the right software and virtual tools, you can offer learners various options on how they obtain information and how they express their understanding. These choices help to engage each learner by providing the right level of challenge (Cast, 2012).

Traditional educational materials are stored on paper in textbooks, on graphs and charts, on maps that can be attached to the classroom wall, on audio tapes, on videotapes and film. Digital content, by contrast, is stored in digital or electronic formats. These include a variety of digital memory technologies are now in existence, ranging from hard drives to flash drives. Due to the power of networks and the Internet, digital content can be stored anywhere in the virtual space.

Just as digital content is transforming the classroom situation; it is also making content providers to explore different techniques of producing and marketing their educational content. Even when ordinary textbooks are digitised, they are embedded with online Uniform Resource Locators (URLs) and Motion Picture Experts Group (MPEG) files. These entrenched rich-media objects demonstrate instead of simply talking about the topic at hand. Professors and teachers at all levels are posting lectures via lecture-capture technologies that permit learners to access class experiences any time they are in need. Similarly, as high-definition and multi-media objects replace flat text, content providers are developing new delivery models, pricing models and software and hardware partnerships to compete in this post-textbook environment. This advancement is providing more options for schools while helping to control costs for institutions as well as for students.

The digital content transformation comprises key changes in both the fundamental nature of educational materials and the medium through which those materials are delivered. For hundreds of years, educational materials have mostly been static text with pictures printed on paper and in books. Flat text and pictures are dated and are being replaced with digital resources. The digital transformation brings us an interactive world of electronic text, animations, illustrations, photographs, audio, simulations and video. Digital educational materials are dynamic and interactive. The conveyance medium is also changing from textbooks to desktop computers, laptops, tablets, smart boards, interactive whiteboards and all manners of mobile, handheld devices.

In an endeavour to mainstream ICT use in the education sector and equip students with modern ICT skills, Kenya's Vision 2030 envisages a computer supply program to schools, colleges and public universities (Government of Kenya, 2008). According to vision 2030 indicators handbook, one hundred and forty schools received computers in year 2009/10 while two hundred schools received computers in year 2010/11. In addition, three hundred schools received computers in year 2011/12 and four hundred schools received computers in year 2012/13.

Development of digital content on Kenyan curriculum is also one of Kenya's vision 2030 flagship projects (Government of Kenya, 2008). This task is undertaken by the Kenya Institute of Curriculum Development. According to the Institute's website

(August, 2013), one thousand and fifty secondary schools were issued with digital content in the year 2011/12 a process dubbed ESP-ICT phase I. Moreover, four hundred and eighty-six secondary schools were issued with digital content in the year 2012/13 named ESP phase II and an additional two hundred and ten for ESP III in the year 2013/2014. In every constituency, one teacher was trained as an ICT champion. The ICT champion has a key role of coordinating the training of other teachers on ICT integration in education.

Based on the information obtained from the Kenya ICT board website (July, 2011), the Board ran a $4 million three-year grant program beginning in 2010 to support the development of local digital content dubbed "Tandaa Digital Content Grant." In particular, the grant sought to support products and services developed for the Internet and mobile phone. Over 25% of Kenyans now have access to the internet, majority of who access the internet through their mobile devices.

The Intel newsroom (April 6, 2011), reported that Intel Corporation and Kenya Institute of Education, currently Kenya Institute of Curriculum Development, launched a joint project to roll out digital curriculum to Kenya schools on March 2011. The collaboration included developing, localizing and distributing digital content to Kenyan schools in order to transform how students interact with the learning resources and their teachers in the classroom. The content value was estimated at ten million dollars aimed at improving access and the quality of primary and secondary education through the effective use of information and communications technology (ICT).

Speaking to Intel newsroom, the Intel Regional manager said that:

> Our continued partnership with Kenya Institute of Education ties in with our mission to increase access to education and improve the quality of education through integration of new technology.
> (*Intel Regional Director in-charge of Africa, Middle East and Turkey, Ms Aysegul lldeniz*)

In his view, the Intel Country manager in Kenya observed that Intel initiatives also offer proven ways to integrate technology into the curriculum for enhanced classroom learning. He noted that:

> By taking a holistic approach to education that includes the effective integration of ICT, we believe that this is a bold step forward to create a sustainable model of education reform and more so a booster to the Ministry of Education efforts to put its implementation of National ICT strategy for Education on the fast track.
> *(Intel Kenya Country Manager, Omar Bajaber)*

Various documents in the education sector have given considerable attention to priorities related to access, quality, equity and relevance of education at all levels. Kenya promulgated a National ICT Policy in January 2006 that aims at improving the livelihoods of Kenyans by ensuring the availability of accessible, efficient, reliable and affordable ICT services. One of the objectives of this policy states that the government will encourage the use of ICT in schools, colleges, universities and other educational institutions in the country so as to improve the quality of teaching and learning (MoIC, 2006). The National ICT strategic plan considers and proposes that ICT can contribute substantially towards realization of accessibility, quality, equity and relevance of education at all levels. In addition, ICT has considerable potential to support implementation of Free Primary Education (FPE) and to address emerging challenges such as; overcrowded classrooms, high Pupil Teacher Ratios (PTRs) particularly in densely populated and semi-arid areas, shortage of teachers on certain subjects or areas, and relatively high cost of learning and teaching materials.

On 12th September 2011, Kenya Institute of Education launched a Curriculum Digitization and e-Learning Strategy (KIE, 2011). The new plan aimed to boost e-learning in public school and give a guideline on how it would be conducted. The strategy provides a blueprint on how learning using digital content like websites, DVDs and computers can be fast-tracked in Kenyan schools. In her own words, the KIE director then said that:

> The success of curriculum digitization and e-learning strategy will lead to improved access, equity, quality and the relevance of Education offered in Kenya.
> (*Lydia Nzomo, KIE Director- 12th September 2011*)

She further revealed that KIE had already digitized content for major subjects in Forms One and Two which were ready for use, adding that content for Forms Three and Four would hopefully be completed by December 2011 to fully unlock e-learning in Kenya. Digitization of Forms Three and Four content was successfully completed and it is already in use in some schools in Kenya. The strategy calls for digitization of curriculum for primary, secondary, Teacher Training Colleges, Technical and Vocational Training Institutions, Adult and Early Childhood Education. It also calls for dissemination of digital content through various mechanisms namely radio, TV, DVDs, CDs, flash disks, mobile devices and internet.

The task-force on re-alignment of the education sector to the 2010 constitution recommended that ICT institutional framework needs to be strengthened to allow efficient integration of ICT in the entire education sector with enhanced ICT capacity at all levels. It also recommended the establishment of a National Centre for ICT Integration in Education (NACICTIE) as a semi-autonomous government agency (SAGA) which should be devolved to county levels. All these efforts suggest that Kenya is ready for digital transformation in its education system.

1.3 Statement of the problem

For hundreds of years, educational materials have mostly been static text with pictures printed on paper and in books (Centre for Digital Education, 2010). In addition, most of the instructional methods the teachers use in classrooms are usually teacher centered and hence give learners fewer opportunities or roles to play in the instructional process (Kiboss, 2000; Tanui, 2003). The UNESCO - Education for All, Global Monitoring Report (2005) notes that practitioners broadly agree that teacher dominated pedagogy where learners are placed in a passive role is undesirable, yet such is the norm in the vast majority of classrooms in Sub-Saharan Africa. The centre for Digital Education (2010) argued that modern education environments require a new model that engages students who are technologically savvy and who expect interactive experiences and desire to learn collaboratively. Educators are looking for ways to increase student engagement, personalize learning and enhance teacher effectiveness.

One way to bring about a change of emphasis in teaching, from the teacher directed approach to a learner centered approach, is to change the medium of instruction (Kearsley, 2000). New teaching and learning strategies and media have continued to evolve many of which favor individualized learning (UNESCO, 2012). According to e-

Republic (2013), Education is in transition whereby schools are now shifting from books to digital curriculum materials and from pencils to devices. Digital curriculum materials allow learners and teachers to personalize and control their learning, giving them a wider range of teaching and learning options than a standard textbook would (Intel Corporation, 2013).

In Kenya, there have been many initiatives geared towards development and provision of digital content to schools to enhance the instructional process and media. Some of these include computer supply to schools' programme (GoK, 2008), provision of digital content to ESP-ICT schools (KIE, 2012) and Tandaa Digital Content grant (Kenya ICT board, 2011) among others. Various policy documents such as the National ICT policy (MoIC, 2006) have also given a considerable attention to development and dissemination of digital content to schools. Institutions like Kenya Institute of Curriculum Development (KICD), Cyber School Technology Solutions, Kenya Literature Bureau, Longhorn Kenya, and Pearson education have heavily invested on development and dissemination of curriculum digital content for use in schools (Ministry of Education, 2014).

Despite all these initiatives to promote development and dissemination of digital content to schools, little has been done to ensure that, the content is actually utilised and the envisaged positive benefits realised. Particularly, the influence of utilisation of curriculum digital content on the instructional process has not been established. In addition, an investigation to determine the influence of the design of digital content being disseminated to schools on the instructional process has not been done. Even where studies have been done such as KICD, (2013), only the level of utilisation of the curriculum digital content was considered. It was, therefore, considered appropriate to investigate the influence of the utilisation and design of curriculum digital content on the Biology instructional process.

1.4 Purpose of the study

The purpose of this study was to investigate the influence of the utilisation and design of curriculum digital content on the Biology instructional process among secondary schools in Nairobi county, Kenya. This entailed establishing the utilisation of the curriculum digital content by learners and teachers, analysing its design and determining how these two factors influenced secondary school Biology instructional process. It was also considered prudent to derive a digital content development model that would lead to design and development of more effective curriculum digital content.

1.5 Objectives of the study

The study was guided by the following specific objectives:

a) To establish secondary school learners' and teachers' utilisation of curriculum digital content in the Biology instructional process.

b) To determine whether utilisation of secondary school curriculum digital content influences the Biology instructional process.

c) To analyse the nature, and influence of curriculum digital content multimedia elements on the secondary school Biology instructional process.

d) To examine the formulation, and influence of curriculum digital content user interface on the secondary school Biology instructional process.

e) To derive a model that can guide the design and development of an effective digital content for secondary school Biology curriculum.

1.6 Research Questions

The study seeks to answer the following research questions: -

a) Do secondary school learners and teachers access and use curriculum digital content for Biology instruction?

b) How does the utilisation of secondary school curriculum digital content influence Biology instructional process?

c) How does the nature of curriculum digital content multimedia elements influence the secondary school Biology instructional process?

d) What influence does the curriculum digital content user interface have on the secondary school Biology instructional process?

e) What kind of a model can be put in place to guide the design and development of effective digital content for secondary school Biology?

1.7 Hypothesis of the study

The null hypotheses that guided this study were the following:

Ho_1: Utilisation of secondary school curriculum digital content has no influence on the Biology syllabus coverage.

Ho_2: Utilisation of secondary school curriculum digital content has no influence on the learners' achievement in Biology.

1.8 Significance of the study

This study is of great significance to learners, teachers, teacher trainers, curriculum developers and even policy makers. Learners will benefit from high quality digital content since this study has come up with ESO model that will guide design and development of effective digital content for secondary school Biology. Teachers will understand how utilisation and design of digital content influences the Biology instructional process. Well formulated user interface and multimedia elements makes use of digital content in the instruction easier. This knowledge will also enable school administrators to make appropriate decisions on the suitability of digital content for their learners.

Teacher trainers in colleges and universities will also find this study very useful. It enhances their understanding on how digital content influences Biology instruction in secondary school. This would enable them to decide how to train the student teachers on the development and use of digital content. They will also be able to develop the necessary ICT experiences that they should expose their student teachers to. The study can help the trainers in selecting digital content with quality elements and appropriate user interface for training the pre-service teachers.

Curriculum development process is normally informed by research. During the curriculum development process, teaching and learning materials in every area are identified. With the relevant information on the influence of curriculum digital content on Biology instructional process from this study, curriculum developers will be in a position to make an informed decision on the inclusion of digital content as a teaching and learning resource. Digital content developers and designers will benefit from the model that has been derived through this study. This will make their work of content design and development easier since the necessary frame work is in place.

Incorporation of digital content in the Kenyan curriculum is one of Kenya's vision 2030 flagship projects (Government of Kenya, 2008). Massive resources have been used to develop digitized curriculum content for Kenyan schools. It is therefore important for the government and other stakeholders to understand the influence of the utilisation of digital content for the instruction process in secondary schools. This will enable proper planning on the future development, dissemination and utilisation of digital content in learning institutions in the country.

1.9 Scope and limitations

This study focused on the development, utilisation and the influence of curriculum digital content on the Biology instructional process in Kenya. Among the factors that were considered in the instructional process are syllabus coverage, assessment and achievement in Biology. Other elements of the Biology Instructional process and other subjects were not considered. The location of the study was Nairobi County in Kenya. Only Form Three learners in selected secondary schools in Nairobi County were involved in this study. The study also involved Biology teachers from the sample secondary schools only. Moreover, only sampled Digital Content developers located within Nairobi County were involved.

This study had some limitations including lack of adequate prior studies on the topic and difficulty in accessing information from digital content designers and developers. The concept of curriculum digital content is relatively new in Kenya. According to MoE (2014), only one digital content development institution has its Biology digital content approved for use in secondary schools besides Kenya Institute of Curriculum Development (KICD) which is the Kenya's national curriculum development centre. Consequently, very little research has been done in this area in the country. Digital content developers were also not very willing to release information on how they develop their digital content possibly out of fear of exposing their confidential information to their perceived and real competitors. They were however assured of the confidentiality of the information they would give. The importance of this study to them was explained to ensure that they understood the reason why they should support it with the necessary information.

1.10 Basic assumptions of the study

The researcher assumed that:

- The information given by the teachers in the questionnaires and the learners during the focused group discussions reflected the true situation in the study schools.
- Digital content developers gave the correct information on content development during their interviews by the researcher.

1.11 Theoretical frame work

This study was based on the Cognitive Theory of Multimedia Learning. The theory as proposed by Mayer (2001) is footed on three main assumptions: there are two separate channels (auditory and visual) for processing information; there is limited channel capacity; and that learning is an active process of filtering, selecting, organizing, and integrating information. According to this theory, humans can only process a limited amount of information in a channel at a time and they make sense of incoming information by actively creating mental representations. Mayer's cognitive theory of multimedia learning presents the idea that the brain does not interpret a multimedia presentation of words, pictures and auditory information in a mutually exclusive fashion; rather, these elements are selected and organized dynamically to produce logical mental constructs. This fundamentally means there is discerning discrimination of auditory and/or visual stimuli. This theory is summarized on figure 1.1.

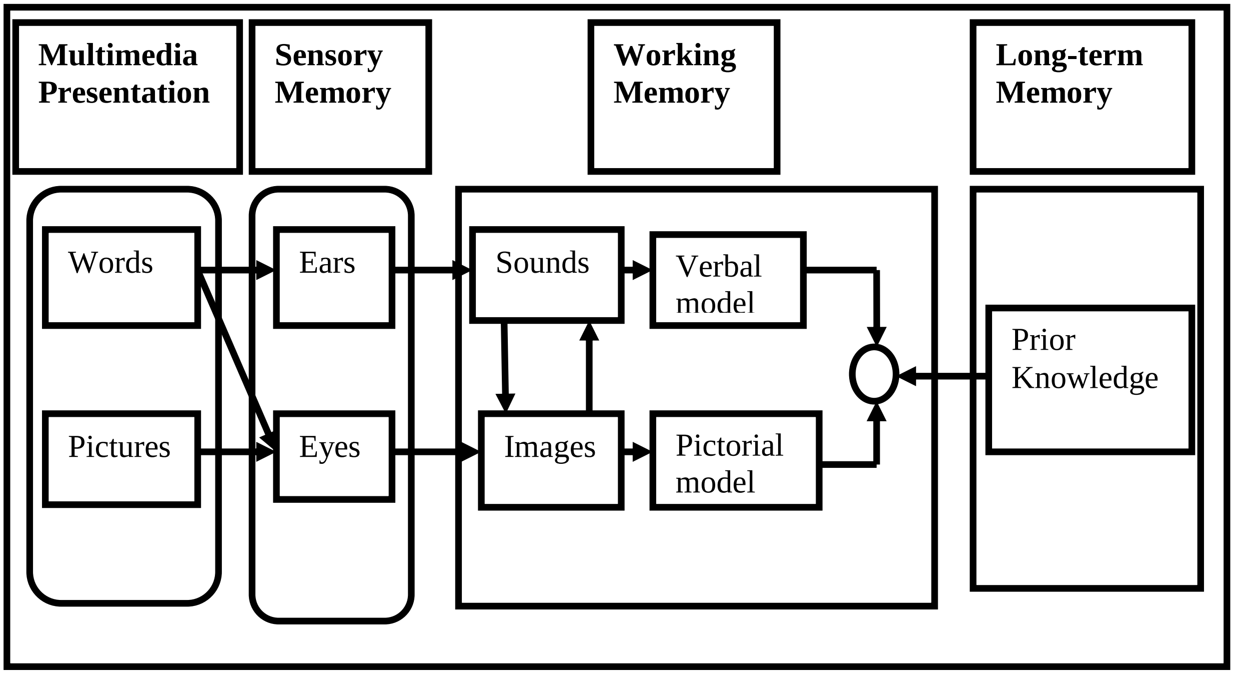

Figure 1.1: Visual representation of the Cognitive Theory of Multimedia Learning
Source: Mayer 2001.

The arrows in figure 1.2 represent the cognitive processing of information. The arrow from words to eyes represent printed words impinging on the eyes; the arrow from words to ears represents spoken words impinging on the ears and the arrow from pictures to eyes represents pictures like videos, animations, illustrations and photographs. The arrows from ears to sounds and eyes to images represent selecting words and selecting images respectively. The arrow from sounds to verbal model represents organizing words while the one from images to pictorial model represents organizing images. Finally, the three arrows from verbal model, pictorial model and prior knowledge represent integrating or merging the information from the three sources.

When information is presented using both the visual and auditory channels, working memory can handle more information overall. Mayer (2005), delineated that people learn more from words and pictures than from words alone. People are therefore likely to learn more through digital content since information is presented in both voice and pictorial formats which utilise multiple channels, that is, visual and auditory channels. Using multiple channels can increase the amount of information that the brain can process (Sweller, 2005). Appropriate digital content consists of both verbal and pictorial presentation. In verbal presentation, digital content has voiceovers or narration of the concepts. In pictorial presentation, it has many elements such as videos, animations, illustration, photographs and electronic text. As a result, digital content uses multiple channels in its presentation of the information. This suggests that digital content can lead to deep learning. If deep learning occurs, then learning outcomes will improve. However, how the information is presented determines how much learning can take place. According to Sweller (2005), too much information delivered in an ineffective manner can interfere with the brain's ability to successfully integrate information into long term memory leading to non-retention of the information.

1.12 Conceptual Frame work

This study investigated how digital content utilisation and design influence the Biology instructional process. In this context, the independent variables were the utilisation and design of curriculum digital content. Utilisation of the digital content involves factors like its access and use which influence the instructional process. On the other hand, design of the curriculum digital content includes factors like its multimedia elements and the user interface. The type, nature and formulation of multimedia elements and user interface in the curriculum digital content influences its utilisation in the instructional process. These design factors also influence various aspects of the instructional process.

The Biology instructional process was the dependent variable. For the purpose of this study, the Biology instructional process consisted of three factors including the syllabus coverage, learners' assessment and achievement in the Biology tests. A change in the independent variables, that is, curriculum digital content utilisation and design leads to a change in the dependent variable, that is, Biology instructional process. For example, an increase in the digital content utilization may lead to increased rate of syllabus coverage, improved mode of assessment and improved learners' achievement.

The dependent variable could also be influenced by extraneous variables which included the teacher; qualification, experience and ICT skills, learners; ability and ICT skills, teaching and learning resources; syllabus, reference materials and laboratory apparatus. The conceptual model of this study is summarised on figure 1.2.

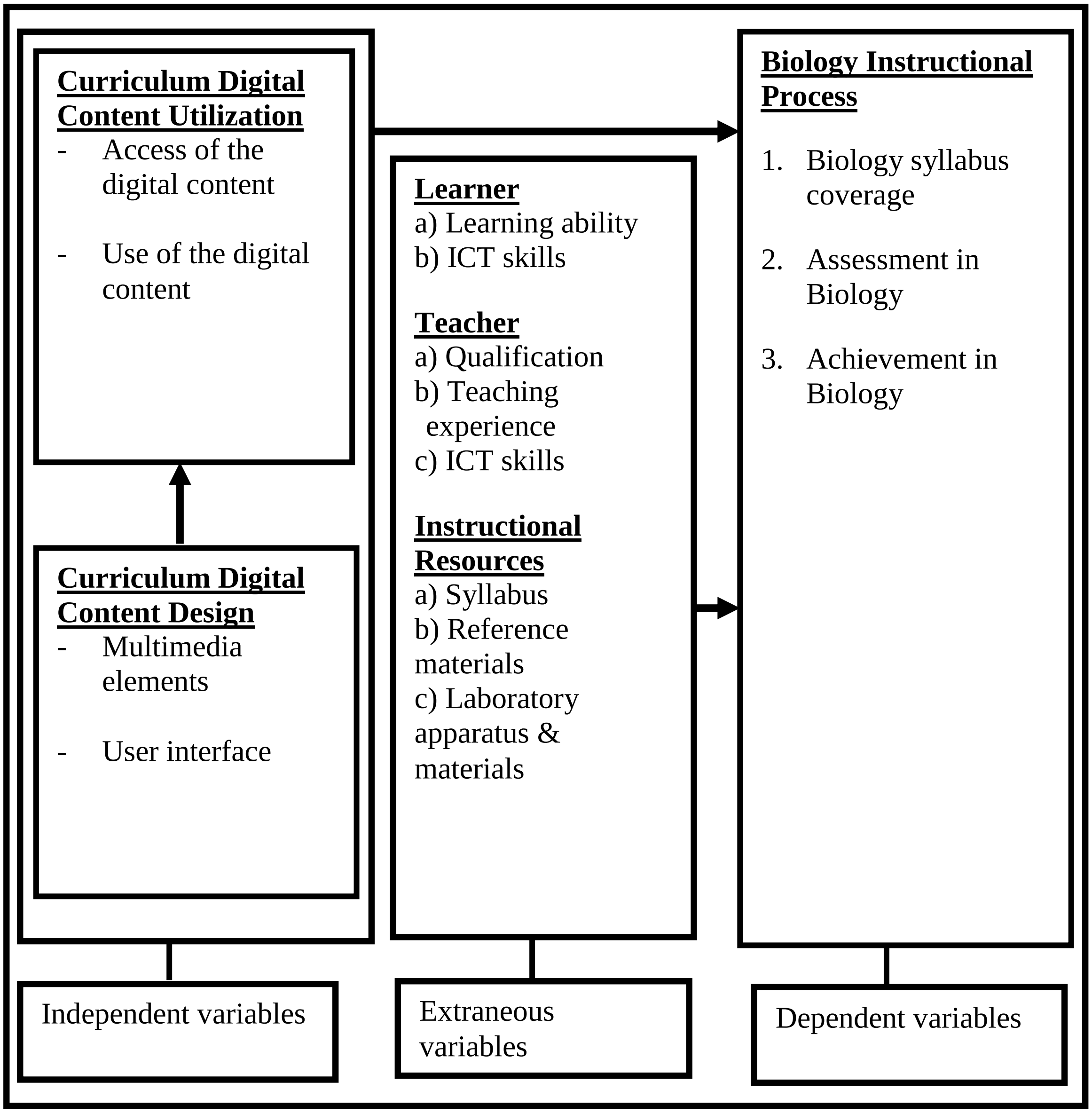

Figure 1.2: Conceptual model of the study.
Source: Developed by the researcher

As pointed out in the theoretical framework (figure 1.2), Mayer (2005) highlighted that learners learn more when both channels are engaged. Well-designed digital content helps learners build more accurate and effective mental models than they do from text alone (Patti, 2005). Since well-designed digital content has both visual and audio elements, it has the ability to stimulate both auditory and the visual channels at the same time. Therefore, utilisation of digital content with well formulated user interface and relevant multimedia elements will have a positive influence on the Biology instruction process.

If during the teaching process the teacher uses an appropriate teaching approach while integrating digital content that has an effective user interface and relevant multimedia elements, then learners are likely to easily understand the Biology concepts. This in turn leads to improved achievement in Biology. However, the process of teaching and learning may be affected by other factors including teacher's qualifications, experience and ICT skills level, learner's ability and ICT skills as well as other teaching and learning resources available. Examples of studies done on the various kinds of variables cited above appear in the next chapter.

1.13 Definition of terms

Assessment - This is the process of gathering, analysing, interpreting and using information about learners' progress and achievement to improve teaching and learning.

Animation - is the rapid display of a sequence of static images and/or objects to create an illusion of movement.

Appropriate digital content - this is content with proper user interface and quality multimedia elements that can be consumed from an electronic device.

Biology - the science of being and existing organisms, including their formation, growth, function, origin, evolution, taxonomy and distribution

Computer assisted Instruction - this is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning.

Digital content - this is any content that can be consumed from an electronic device such as personal computer, mobile devices or digital television**.**

e-Learning - this is the delivery of a learning, training or education programme by electronic means.

e-Republic - this is a California based media and research company that focuses exclusively on the state, local government and education

Economic Stimulus Programme (ESP) - this was a development plan initiated by the Government of Kenya to boost the economic growth and lead the Kenyan economy out of a recession.

Graphical User Interface - is the means in which a person controls a software application or hardware device through graphical icons or visual indicators.

Illustration - this refers to a picture, a design or a diagram.

Information Communication Technology - this refers to all the technology used to handle telecommunications, broadcast, media, management systems, audio-visual processing and transmission systems and network based control and monitoring systems

Influence - this refers to an effect or influence on someone or something

Instructional process - this is the process which starts with the definition of what the learners should know and finishes with the evaluation of what the learners actually know.

Intel Corporation - this is an American multinational technology company headquartered in Santa Clara, California and the largest and highest valued semiconductor chip makers.

Learning - acquisition of knowledge, skills and attitudes that results in observable change in behaviour or capability

Moving pictures Experts Group (MPEG) - this is a working group of authorities that was formed by ISO to set standards for audio and video compression and transmission

Portable Document Format (PDF) - This is a file format used to present documents in a manner independent of application software, hardware and operating systems.

Teaching method - this is a body of skills or techniques which a teacher involves his/her students in during the process of presenting the content of the lesson.

User interface (UI) - this is the means in which a person controls a software application or hardware device.

Uniform Resource Locator (URL) - this is a unique address for a file that is accessible on the internet.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

A literature review is an account of what has been published on an area by accredited researchers and scholars (Kombo and Tromp 2006). It is a critical look at the existing research that is relevant to the study that the researcher will be undertaking. This chapter presents the literature that was reviewed in relation to the objectives of the study. In this study, the literature review is organized into various sections including: Biology and the instructional process, digital content and the instructional process, instructional and multimedia design models and a summary of the literature review.

2.2 Biology and the Instructional process

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, origin, evolution, distribution, and taxonomy (Aquerena wetlands project, 2013). According to Vernon (1995), Biology is a vast subject containing many subdivisions, topics, and disciplines. Among the most important topics are five unifying principles that can be said to be the fundamental axioms of modern Biology. These principles include: cells are the basic unit of life, new species and inherited traits are the product of evolution, genes are the basic unit of heredity, an organism regulates its internal environment to maintain a stable and constant condition and living organisms consume and transform energy.

Sub disciplines of Biology are acknowledged on the basis of the scale at which organisms are studied and the techniques used to study them: biochemistry surveys the fundamental chemistry of life; molecular Biology examines the composite interactions of systems of biological fragments; cellular Biology observes the rudimentary building block of all life, the cell; physiology studies the chemical and physical functions of the tissues, organs, and organ systems of an organism; evolutionary Biology investigates the processes that have led diversity of life; and ecology examines how different organisms intermingle and associate with their environment (Weber state museum of natural life science, 2012).

KIE (2002) indicated that Biology should be taught and learnt as science subject at secondary school level in Kenya. The teaching and learning activity can be considered as a practice called the instructional process, which begins with the definition of what the learners should know and is completed by the evaluation of what the learners actually know (Dick and Carey, 2008). Basically, the teacher has to decide what to teach, and how to teach, that is, the teacher has to select contents, techniques and resources of the teaching activity including integration of ICT in instruction. Petrone, Bruni, Confrancesco and Caldirola (2011) pointed out that the instructional process has several basic steps which include analysis, preparation, implementation, evaluation and revision. Analysis encompasses identifying instructional goals and defining specific instructional objectives while in preparation, picking of instructional methods and designing instructional stratagems is done. During implementation; Crafting, assembling, reviewing and dissemination of instructional materials is done. Evaluation comprises checking what learners actually have learned while referring to the desired instructional objectives. Finally, revision which involves reviewing instructional analysis, objectives, methods, strategies, and materials, to improve the learning performance is done if the results are not satisfactory. McGraw-Hill (2014) on the other hand, argues that the instructional process comprises three basic steps. The first is planning for instruction, which includes identifying specific expectations or learning outcomes, choosing materials to nurture these expectations or outcomes, and organizing learning experiences into a rational, reinforcing structure. The second step comprises of delivering the planned instruction to learners that is, teaching them. The third step involves measuring how good learners learn or attain the expectations or outcomes. To be able to design and implement the instructional process in Biology, the necessary instructional resources need to be available. It is therefore important to study the accessibility of digital content to teachers and learners which is one of the teaching learning resource required especially where ICT integration is to be applied as an instructional technique.

2.2.1 Aims and objectives of secondary school Biology

According to KIE (2002), the study of Biology aims at equipping the learner with knowledge, skills and attitudes that are necessary for controlling and preserving the environment. It also enables the learner to appreciate humans as part of the broader community of living organisms and is a foundation for careers in health, agriculture environment and education. In addition, it is the precursor of biotechnology which is a tool for industrial and technological development.

In the secondary school Biology syllabus, KIE (2002) identified the objectives that a learner should acquire after going through the four-year Biology course at the secondary school cycle. These objectives include ability to communicate biological knowledge in a precise, clear and logical manner; develop an understanding of interrelationships between plants and animals and between humans and their environment; apply the knowledge gained to improve and maintain the health of the individual, family and the community; relate and apply relevant biological knowledge and understanding to social and economic situations in rural and urban settings; observe and identify features of familiar and unfamiliar organisms, record the observations and make deductions about the functions of parts of organisms; develop positive attitudes and interest towards Biology and relevant practical skills; demonstrate resourcefulness, relevant technical skills and scientific thinking necessary for economic development; design and carry out experiments that will enable them understand biological concepts; create awareness of the value of cooperation in solving problems; and acquire a firm foundation of relevant knowledge, skills and attitudes for further education and for training in related scientific fields. Utilization of ICTs such as digital content in the Biology instructional process could perhaps enhance achievement of some of these objectives. An example of areas where ICTs could boost achievement is the communication of Biological knowledge and technological development. As such, the study of the influences of utilisation of the Biology digital content in the instruction process is momentous.

2.2.2 Secondary school Biology content overview

KIE (2002) points out that secondary school learners should cover a total of seventeen topics in Biology during their four year course. The topics are arranged according to the classes in which they are supposed to be covered. In Form One; the learners should cover five topics which include: Introduction to Biology, Classification 1, the cell, Cell physiology and Nutrition in plants and animals. In Form Two, four topics need to be covered including: Transport in plants and animals, Gaseous exchange in plants and animals, Respiration, Excretion and Homeostasis. In Form Three, the learners ought to cover four topics. These are: Classification II, Ecology, Reproduction and Growth and development. Finally in Form Four, the learners should cover four topics which are: Genetics, Evolution, Reception, Response and Co-ordination in plants and animals and Support and movement in plants and animals. This study considered the thirteen topics that should be covered up to Form Three since the target population was the Form Three learners. To cover this content effectively, proper instructional techniques and resources including the new and emerging ones should be utilized. One of the new instructional techniques is ICT integration while digital content is an emerging resource which is very useful in the instructional process. Hence, one of the objectives of this study was to investigate the access and utilisation of Biology digital content in the instructional process.

2.2.3 Biology teaching methods, resources and assessment

KIE (2006) defined methodology as a set of methods used in presenting the subject matter with an aim of achieving different specific objectives. The methods used in the teaching and learning of Biology include: practical activity, class discussion, demonstration, field trip and project.

Maundu et al., (2005), indicated that a teaching method is a body of skills or techniques, which a teacher involves his or her learners in during the process of delivering the content of the lesson. They argue that a number of teaching methods are available and all are useful at one time or another depending on the prevailing circumstances and the objectives which the teacher intends to achieve. They identified various teaching methods including the lecture, demonstration, practical or laboratory experiments, project and field trip.

A classroom teacher requires various kinds of teaching resources to enhance the effectiveness of his or her instruction (Maundu et. al, 2005). They listed textbooks, journals, magazines, apparatus, chemicals, charts, models, photographs and motion pictures as some of the resources that can be used in teaching and learning Biology. According to KIE (2006), resources are the materials and equipment which are used to enhance learning by experience. They enable the learners to actively participate in the learning process. The suggested basic resources include apparatus, models, chemicals and reagents.

KIE (2002) in the secondary school Biology syllabus identified various assessment methods including: practical work, project work, field trips, oral questions, quizzes and written tests and examinations. According to the MoE (2011), there is a lot of software available in the market to assist with student assessment. Some of them include:

- The Castle toolkit, available at http://caacentre.lboro.ac.uk
- Hot Potatoes software, available at http://www.halfbakedsoftware.com
- Wida Authoring Suite, available at http://www.wida.co.uk
- Hyperstudio, available at http://www.hyperstudio.com

Virtual learning environments commonly include tests tools suitable for formative assessment. Elements of such environments are specifically designed to manage the process of setting, collecting and returning assignments (MoE, 2011). There are other alternative instructional resources that can be used in the instructional process. An example of such resources is the digital content. It was thus vital to investigate whether teachers and learners actually access and utilize such resources in the Biology instructional process.

2.2.4 Use of ICT in the Biology Instructional Process

Information Communication Technology (ICT) has developed to be the basic building block of modern society in recent years (Daniels, 2002). It has become an ordinary entity in all aspects of life education included. ICT cover telecommunications equipment and services, media and broadcasting, Internet service provision, information technology equipment and services, libraries and documentation centres, network-based information services and other related information and communication activities (UNESCO, 2002).

There are numerous ICTs existing and which are relevant to education. Such products have been used in education for different purposes, and include: television lessons, Interactive and multimedia content, teleconferencing, internet services, audio conferencing, radio broadcasts (Bhattacharya and Sharma, 2007). In education context, Ogange (2011) defined ICT as devices, technologies or solutions that are applied in addressing education needs and problems facilitated by both old technologies like radio, telephone, television and audio tapes as well as, new digitised formats such as computers, internet and hand held devices.

Many scholars, teachers and teacher-trainers generally agree that ICT has a great potential of enhancing teaching and learning. A number of articles about the use of ICT in teaching and learning have been published (Bell and Bell, 2003). In Biology use of ICT for instruction can raise not only the level of knowledge but also the learners' attitude towards the subject (Kubiatko and Halakova, 2009). Biology teachers need to distinguish the two categories of applications that can be used for Biology instructional purposes. The first category includes generic applications that are utilised in all subjects, such as office applications, internet search, communication using e-mails, and multimedia presentations. In this case if a Biology teacher does not use ICT in a classroom, damage to the learners is limited because they can achieve missing skills from other subjects or even ICT lessons (Kuhlemeier and Hemker, 2007). In the second category are applications adapted or customized to be used in Biology teaching (McFarlane and Sakellariou, 2002). Examples of such applications include imaging systems in microscopy (Fiche, Bonvin, and Bosman, 2006) and virtual laboratory and dissections (Jenkins, 2004; O'Byrne, Patry, and Carnegie, 2008). In addition, there simulations applications (Ramasundaram, Grunwald, Mangeot, Camerford and Bliss, 2005) and real laboratory exercises with data acquisition systems (Šorgo, Hajdinjak and Briški, 2008).

All these applications may be generally referred to as Interactive digital content or resources. If a Biology teacher does not utilise such applications in teaching learners in most cases they would not be able to compensate loss with work in other subjects such as computer studies or ICT. Studying the influence of interactive digital content on Biology instruction is significant since it is one of the category applications.

2. 3 Digital Content and the Instructional Process

Digital Content is any content that can be expended from an electronic device such as computer, mobile phone, game console or digital television (Kenya ICT board, 2011). According to Cast (2012), digital content includes text, images, sounds, and video that have been digitized. Digital content refers to information that is published and distributed in a digital and electronic form. It can include text, figures, sound recordings, photographs, images, videos and software (MoE, 2011). The definition of what constitutes digital content has distended, inspired by innovative technologies, and stretched to include resources that benefit reading learners, lecture learners, auditory learners and visual learners. It's a far cry from what digital content meant only a few years ago which involved providing content in PDF or supplementary material on a CD-ROM. Digital content currently can fully engage and interact with learners while saving a lot of resources (Centre for digital education convergence, 2010). Digital content thus consists of different formats, multimedia elements and user interfaces that make it interactive, engaging and interesting.

2.3.1 Digital Content Design

According to Kenya's Ministry of Education (2011), Digital content is available in two main formats namely web-based format and computer-based format. Web-based formats include websites, education portals and content developed on learning management systems. It is mainly available online. Computer-based formats include CDs, DVDs, content and software installed on computers and servers. This type of content is mainly available offline. The main components of the digital content design are the multimedia elements and user interface.

2.3.1.1 Multimedia elements

There are different types of multimedia elements that are used for instructional purposes. Multimedia is the use of text, graphics, animation, pictures, video, and sound to present

Information (Najjar, 1996). Ministry of Education (2011), observed that digital content has a visual appeal and hence it enhances the visual aspect of learning through the use of different multimedia elements which include videos, animations and photographs. Digital content can be personalized to each learner's learning style; whether they learn best using text, video, audio, or pictures (Intel Corporation, 2013). On the same vein, Southern Regional Educational Board (2005) noted that elements such as video, audio, animation or other rich media must be functional and should be available in one of the commonly used formats, such as QuickTime or Real Media. Video might help one student grasp new concepts, for example, while another might learn better by using audio or pictures. This emphasizes the importance of a variety of multimedia elements in the curriculum digital content to enhance the learning process. Studies on the multimedia elements in the curriculum digital content accessible in Kenyan schools are not available. Due to the cited importance of multimedia elements in any digital content, this study found it crucial to analyse the multimedia elements in curriculum digital content and how they influence secondary school Biology instructional process in Kenya.

2.3.1.2 User Interfaces

User Interface varies greatly across types of digital content and devices, for example, online services, e-books, tablet apps, iPad apps, smart phone apps, iPhone apps, and cross-device apps. The increase of screen types and sizes makes UI once more a front and centre issue for digital content (Dilanchian, 2012). An effective UI creates modest advantage in the utilisation of digital content. Digital content developers appreciate that today differences between screens affect user experience with content. User experience differs in numerous ways for content between tablets, smart phones, e-readers, laptops and desktops.

Jisc Digital Media (2013) noted that the primary goal of any digitisation project is to enable its users to have efficient and rewarding access to the content. The content may be excellently digitised and assembled, but if the UI is poor, it is unlikely to be much used. All too often, those planning digitisation tasks focus more on their content and its characteristics than on their users' needs. In some instances, this leads to a hastily designed UI and a struggle to find some users and convince them that they can benefit from the resource. A much better approach is to assess your users' needs at the beginning of the project, permitting them to edict which content or parts of content you digitise and the functionality you require from your delivery UI. Instead of being an afterthought, the UI should be sketched out at the very beginning and should inform the way you digitise and index your digital content.

University of Oregon (2013) identified various steps to ensure that digital content has a user-friendly interface. These include: locating the primary navigation in an easily noticeable area, preferably next to the main body of the page; standardizing the appearance of the navigation to make it easy to discriminate this critical component from everything else on the page and grouping comparable navigation items next to each other. Grouping helps users distinguish among similar or related categories. In addition, University of Oregon (2013) emphasises that developers should not provide compound navigation areas for the same type of links. Groups that are too similar can fragment and complicate the interface. They should also not use concocted words for category names. Categories need to be easily distinguishable from each other.

Despite the critical role of the user interface in digital content, the types of UI in curriculum digital content in secondary schools in Kenya have not been studied. In addition, the influence of curriculum digital content UI on its utilization and efficacy in the Biology instruction process has also not been scrutinised. This study therefore examined the user interfaces in the Biology digital content accessible in Kenyan schools.

2.3.2 Importance of digital content

The centre for digital education (2010) special report points out that digital content can fully engage learners while saving a lot of resources. The textbook is not necessarily bad or ineffective, and it can certainly have its benefits. However, times have changed and a new set of realities is shifting the textbook's role as content king. Textbooks are expensive, inflexible and heavy. They can limit learning as they are not dynamic and they fall short of inspiring stimuli-driven students. Modern education environments require a new model that engages learners who have technological knowledge and who expect interactive learning and wish to learn collaboratively.

SEG Research (2008) submitted that digital educational materials are active and alive. The delivery medium is also changing from textbooks to desktop computers, laptops, tablets, net books, interactive whiteboards and all manner of mobile, handheld devices. As for what digital materials can do, it is undoubtedly not limited to static presentations of information. In the digital world, content can be active and interactive. Content can be linked to other materials on the Internet in a way that permits learners to explore. And content can demand responses and answers from the student to promote timely self-assessment and immediate feedback.

Ministry of education (2011), in its ICT integration manual identified various merits of digital content. Some of the merits are that digital content has a visual appeal therefore enhances the visual aspect of learning through the use of different multimedia elements which include videos, animations, photographs, etc. It is also interactive and therefore the learners take charge of the learning process in terms of using their ability to determine the pace of learning. In addition, collaboration is enhanced when using digital content, that is, in online format and the content allows for easier search of related content. It has support menu such as a ‘Help’ function that enables the learner to get assistance when faced with problems. Moreover, online digital content is flexible in that its accessible anywhere, any time. Digital content also allows quick search and selection of the content one wants to use in teaching and learning process and also the content is easier to review, update and disseminate. Despite the underscored eminence of digital content, its influence on the instructional process in the schools in Kenya has not been addressed. This study therefore investigated the influence of the utilisation of digital content on the Biology instructional process

2.3.3 The place of digital content in the world, Africa and Kenya

Digital content development and utilization in schools has been embraced in many countries across the world. BBC news (2012) reported that South Korea, which is one of the world's highest-rated education systems, aimed to consolidate its position by digitizing its entire curriculum. By 2015, the country desires to be able to deliver all its curriculum materials in a digital format through computers and other ICT devices. The information that would once have been in paper textbooks will be delivered on screen.

In 2012, South Korea's Minister for Education, Science and Technology, Ju-Ho Lee, said that his department was preparing a promotion strategy for "Smart Education", focusing on customized learning and teaching. He pointed out that:

> The transfer from the traditional paper textbooks to digital textbooks will allow students to leave behind their heavy backpacks and explore the world beyond the classroom. The intended benefits include extending the choice of subjects for students in rural areas who previously have lacked specialist teachers and to make it easier for pupils to study from home.
> *(South Korea's Minister for Education, Science and Technology, Ju-Ho Lee)*

The United States, alarmed by its relative international educational decline, is now also increasing the resources it devotes to digital learning (BBC news, 2012). The Centre for digital education (2010) reported that the primary driver for this transformation is the challenge that global competitiveness in the 21st century presents to our educational system. To be prepared to meet the challenge of global competitiveness, our students need to be well-versed in sciences, mathematics and humanities. While the world around us has been rapidly transforming itself through information and digital technologies, and industry after industry have remade themselves with technologies, some teachers still educate children using a centuries-old model of educational content delivery and curriculum presentation.

The centre for digital education (2010) argued that:

> Classroom textbooks may soon be retired to museum displays. In the coming years, a young person going through the American History Museum will find a United States History textbook in the past technologies section. Placed next to button hooks, typewriters and buggy whips, the textbook could prompt the incredulous question, "Is that how granddad learned about American History?" (*Centre for digital education, 2010*)

This could sooner or later be a reality as increasing numbers of educators replace the class textbook with technology-driven alternatives based upon digital content that can better engage students and offer more meaningful learning experiences. In America, Leadership is taking shape at the national level. Early in 2010, the U.S. Department of Education released its National Educational Technology Plan, which is focused on digital content development. Its seven action steps are a must-read for state and local educational leaders.

National Digital Learning Resources Network (NDLRN) of Australia partnered with the Australian Children's Television Foundation (ACTF) and Real-Time Health to make available to teachers and learners across Australia, a wide range of digital resources. The two separate sets of resources will add to the pool of content that

NDLRN develops and distributes to education jurisdictions across Australia (http://www2.curriculum.edu.au).

According to Intel Corporation (2011), Intel® skoool™ Learning and Teaching Technology, an interactive Internet resource for learning Mathematics and Science, has been promoted in countries like South Africa, Egypt, Libya, Nigeria, Zambia, Ghana and now Kenya. Intel® skoool™ Learning and Teaching program provides teachers and students online access to science and mathematics resources and tools set in an engaging, multi-media environment to help improve learning.

Intel Corporation and Kenya Institute of Education launched a joint project to roll out digital curriculum in Kenya schools on March 2011. As part of this effort, Intel and KIE have collaborated on developing localized digital content for Learning and Teaching Technology that provides teachers and students' online access to science and mathematics resources and tools set in an engaging, multi-media environment to help improve learning (Intel Corporation, 2011). Kenya has developed digital content for all levels in secondary school through the Kenya Institute of Curriculum Development. This digital content is being utilised in various schools in the country. One of the major programmes that has boosted the access and utilisation of curriculum digital content in the secondary schools in Kenya is the ESP-ICT programme.

2.3.4 The ESP-ICT Programme in Kenya

In line with Government policies, the ESP-ICT programme for schools was initiated in 2009 (KICD, 2013). It aimed at enabling schools and teachers to use modern technologies in their preparation and delivery of curriculum in order to enhance access and promote quality of education. The MoE was to carry out training of teachers at the school level and provide digital content developed by Kenya Institute of Curriculum Development (KICD). In addition, schools were to be supplied with the latest software applications for installation in the computers for free. It was envisaged that once these technologies were deployed, they would be fully utilised by every teacher in the most productive and efficient manner so that learning becomes more exciting, dynamic and participatory.

The ESP was organised in phases, ESP 1 involving 1050 schools (5 secondary schools per constituency) and later ESP 2 with an additional 486 schools. District Education Officers (DEOs), guided by the set criteria identified the schools that benefited. They also oversaw the procurement processes to ensure that the right equipment and software were obtained. Further, they assigned ICT champions within the districts to provide first-line professional support to the beneficiary schools. The 210 ICT champions (one per constituency) were expected to train a minimum of 10 teachers in each of the 5 schools in their constituencies. They were trained and issued with training manuals developed by MoE. They were also expected to send regular training reports to the MoE. Heads of identified schools were taken through training by Kenya Education Management Institute (KEMI) on how to integrate ICT in the teaching and learning process.

On their part, selected schools were allocated funds to cater for a comprehensive ICT package; they each procured 11 computers, 1 laptop, 1 printer, 1 LCD Projector, 1 UPS, and installation of Local Area Network and internet connectivity for one year. Principals and Boards of Governors were tasked to ensure security of the ICT infrastructure procured under this programme. They were also to ensure capacity building for their staff; that teachers integrate ICT in their teaching; and take responsibility for servicing and maintenance of the procured ICT infrastructure after the warranty period. Monitoring and evaluation guidelines were produced to ensure that the programme stayed on course. Despite all this arrangement; providing schools with ICT infrastructure, capacity building teachers and even providing them with first line technical support, little was done to ensure that the digital content that was being supplied to these schools was of high quality and well designed. It was therefore found appropriate to analyse the curriculum digital content provided to these schools in terms of its quality and influence in the Biology instructional process.

2.4 Instructional and Multimedia design models

Instructional design models are visual or verbal representations of the instructional design process that are used to guide and complete design in many training and educational settings (Seels and Glasgow, 1998). An instructional design model gives structure and meaning to a design problem, enabling the would-be designer to negotiate the design task with a conscious understanding (Ryder, 2014). A model therefore offers its user a means of comprehending an otherwise incomprehensible problem. Various instructional and multimedia design models have been developed by scholars. However, a specific model for curriculum digital content design and development in Kenya has not been developed hence the need for one as presented in this thesis.

2.4.1 Instructional design models

There are various models which have been developed to guide the process of instructional and multimedia design. ADDIE is one of the oldest instructional design models (Watson, 1981). This model first appeared in 1975 and was created by the center for Educational Technology at Florida State University. The center identified five common components and developed the popular ADDIE model with the following five logical steps: analyze, design, develop, implement, and evaluate. The model originally consisted of 19 steps that were considered essential to the development of education and training programmes but were later grouped to form five phases (Hannun, 2005). ADDIE model formed the foundation for development of ESO digital content design and development model that was derived in this study. Greer (1992) introduced a ten-step instructional design Project Management Model. The ten steps include the following: determine project scope, organize the project, gather information, develop the blueprint, create draft materials, test draft materials, produce master materials, reproduce, distribute, and evaluate.

Dick, Carey, and Carey (2001) developed a ten-step interactive process reference. The ten steps include: Identify instructional goal(s), conduct instructional analysis, analyze learners and contexts, write performance objectives, develop assessment instruments, develop instructional strategy, develop and select instructional materials, design and conduct formative evaluation of instruction, revise instruction and design and conduct summative evaluation. Morrison, Ross, Kemp and Kalman (2007) developed a nine-step instructional design model which is described as a comprehensive instructional design plan. The steps of this model are: identify instructional problems, and specify goals for designing an instructional program, examine learner characteristics that should receive attention during planning, identify subject content, and analyze task, components related to stated goals and purposes, state instructional objectives for the learner, sequence content within each instructional unit for logical learning, design instructional strategies so that each learner can master the objectives, plan the instructional message and delivery, develop evaluation instruments to assess objectives and select resources to support instruction and learning activities.

2.4.2 Multimedia design models

In the field of design and development of multimedia, Stoney and McMahon (1998) identified the four-basic phase's model. These are information design including the planning of the content and an analysis of the audience, interface design which connects the learner with the content in the most functional and intuitive way possible, navigation to connect the pages of content in a logical structure and interaction design which determines how the program works and how the learner uses the program. Alessi and Trollip (2001) also identified a four-phase model including presenting information, guiding the learner, practicing, and assessing learning. Frey and Sutton (2010) came up with a ten step multimedia projects development model. The steps included: definition the instructional goals, objectives, and audience, review and investigate the existing options, determine format, budget, and timeline, determine the content, activities, and assessment strategies, develop evaluation strategies, criteria, and instruments to determine the effectiveness of the project, develop the flowchart, site map, and/or storyboard, develop a prototype, perform a formative evaluation, complete the design, and perform a summative evaluation of product and process.

2.5 Summary of literature review

One of the aims of secondary school Biology education as outlined in the KIE (2002) syllabus is that, it is the precursor of biotechnology which is a tool for industrial and technological development. The syllabus also identifies communication of Biological knowledge in a precise, clear and logical manner. For technological development and good communication, ICT is required as a 21st century skill. A review of the resources that should be used in teaching and learning Biology reveals that ICTs are not included. In addition, digital content is not discussed as a teaching and learning resource. The syllabus and various authors also provide methods which should be used to cover Biology content in secondary schools. ICT integration which is a key teaching methodology in this technological generation is however not included. A key component in ICT integration in the instructional process is the curriculum digital content. It has many advantages including its interactivity, visual appeal and provision of immediate feedback to learners among others. Consequently, it was essential to investigate teachers' and learners' access and utilisation of Biology digital content and its influence on the Biology instructional process.

Various assessment methods in Biology including practical work, project work, field trips are also identified in the syllabus. MoE (2011) pointed out that there is a lot of software available to assist in student assessment. Elements of these software are designed to manage the process of setting, collecting and returning assignments.

According to SEG research (2008), digital content can demand responses and answers from the learner to promote timely self-assessment and immediate feedback. These features of digital content may improve the frequency of assessment as well as the duration taken to give feedback. Details on the availability of such features in the secondary school curriculum digital content were not provided. As a result, it was crucial to investigate whether the Biology digital content provided in the secondary schools has such features and if they have any influence on the Biology instructional process.

According to MoE (2011), digital content enhances visual aspect of learning through the use of different multimedia elements which include videos, animations and photographs among others. Digital content can be personalized to each student's learning style whether they learn best using text, video, audio or pictures (Intel Corporation, 2013). For example, video might help one student grasp new concepts while another might learn better by using audio or pictures. These findings however did not give the details on the variety and adequacy of multimedia elements in the curriculum digital content being utilised in secondary schools. Information on the relationship between the multimedia elements in the digital content and its utilisation among learners and teachers were not provided. Consequently, this study analysed the different types of Biology digital content in the secondary schools in terms of their multimedia elements. Through the interaction with learners and teachers, the study established their preferred multimedia elements and how these elements affect their utilisation of Biology digital content.

Jisc (2013) observed that when planning digitisation, digital content developers concentrate more on the content and its characteristics than their users and their needs. Noric (2012), noted that user interfaces vary greatly across the types of digital content and devices. According to Jisc Digital Media (2013), content may be superbly digitized and compiled, but if the user interface is poor, it is unlikely to be much used. In the reviewed literature, information on the user interfaces used in secondary school Biology digital content was not available. Details on their influence on the Biology instructional process were also not provided. This study thus analysed the different user interfaces in the Biology digital content in the secondary schools to assess their suitability in the Biology instructional process.

The government and its partners such as Intel Corporation have heavily invested to facilitate development and provision of digital content to schools in Kenya. The establishment of the ESP-ICT schools was a major boost to access and utilisation of digital content by teachers and learners in secondary schools (KICD, 2013). Although in this project factors like ICT infrastructure, capacity building of teachers and provision of digital content were taken care of, content design factors such as nature of multimedia elements and formulation user interface were not considered. A study done by KICD (2013) shows that only 38% of the ESP schools were using the Institute's Biology digital content in the country. This study did not look at the factors that led to low utilisation of the Biology digital content. University of Oregeon (2013) identified various steps to ensure that digital content has a user-friendly interface. However, details on the process of development and design models that would enhance development of appropriate

Biology digital content are not given. As such, there is no specific model in place to guide the process of curriculum digital content design and development. This study therefore sought to analyse the digital content development process and then derive a model that would guide the development of effective digital content. The next chapter presents how the study was actually carried out.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter mainly focuses on the design and methodology that was used in this study. It includes the research design, location of the study, target population, the sample and the sampling procedures, research instruments-their design and validation, data collection procedures and the methods used in analysis and presentation of findings.

3.2 Research design

A research design is a structure of research. It is the glue that holds all the elements in a research project together (Kombo and Tromp, 2006). It constitutes the blueprint for the collection, measurement and analysis of data (University of Southern California, 2015). This study used a mixed methods approach where the triangulation design was applied. The purpose of triangulation design is to obtain different but complementary data on the same topic to best understand the research problem (Morse, 1991). Greene, Caracelli and Graham (1989) defined mixed-method designs as those that include at least one quantitative method (designed to collect numbers) and one qualitative method (designed to collect words). Johnson, Onwuegbuzie and Turner (2007) termed mixed methods as a type of research in which a researcher combines elements of qualitative and quantitative research approaches such as use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques for the purposes of breadth and depth of understanding and corroboration.

Triangulation is the most common and well-known design in mixed methods approach (Creswell, Plano-Clark, Gutmann and Hanson, 2003). Mixed methods design has various advantages. University of Southern California (2015) outlined the following merits of mixed methods: narrative and non-textual information can add meaning to numeric data, while numeric data can add precision to narrative and non-textual information, can utilize existing data while at the same time generating and testing a grounded theory approach to describe and explain the phenomenon under study and may perhaps provide stronger, more robust evidence to support a conclusion or set of recommendations.

To obtain sufficient data required to deal with the research problem in this study, both qualitative and quantitative data was essential. As highlighted by Creswell et al. (2003), triangulation design involves concurrent but separate collection and analysis of quantitative and qualitative data so that the researcher may best understand the research topic. In the case of this study, data on the learners' achievements and syllabus coverage was quantitative and yet vital. Similarly, data on digital content utilization, design and even leaners assessment was qualitative but also very significant for this study. A combination of data collection instruments was also utilised in this study. Both textual data, for example the one obtained through interviews and focus group discussions and numeric data such as learners' achievement and syllabus coverage acquired through documents analysis were collected. In addition, the study used existing information from the official school documents such as the records of work and progress records while generating new data through interviews, questionnaires, focused group discussions and analysis of Biology digital content. University of Southern California (2015), pointed out that mixed methods approaches can utilise existing data while at the same time generating new information. In data analysis, both descriptive and inferential statistics were used. Based on this, triangulation design, which is a mixed methods approach was the most appropriate for this kind of study.

ESP-ICT secondary schools in phase I and digital content developers in Nairobi County were involved in the research. Biology Teachers provided information by filling questionnaires regarding syllabus coverage, assessment, learners' achievement and Biology digital content availability and utilisation in their schools. Biology digital content was then analysed in terms of the multimedia elements and user interfaces and the information recorded using the digital content analysis sheet. Learners' focus group discussions were then held. The learners in the focus group discussions were randomly selected from the Form Three classes. They gave information on how and the formats in which they accessed and utilised Biology digital content. In addition, they were asked what they thought about Biology digital content in terms of syllabus coverage, assessment and their achievement in Biology. Learners were further probed to give information on the various UI in Biology digital content and their preference.

Various documents were analysed to determine syllabus coverage as well as learners' achievement in Biology. Teachers' records of work and learners' notes were examined to determine syllabus coverage. This assisted in comparison of syllabus coverage between groups that use digital content and the ones who don't utilize it. Progress records were analysed to enable the study establish whether there was any difference in

Biology achievement between the learners who utilize digital content and the ones who didn't use. The school was also observed to establish whether in deed the stated devices were available and being used. Digital content developers within Nairobi County were then interviewed to establish the procedure they follow in the design and development of their digital content. The researcher also sought to find out the UI they use in their digital contents. This enabled the researcher to understand the various content development processes used by developers and come up with a model that can guide development of appropriate curriculum digital content. Figure 3.1 shows the Triangulation design used in the study.

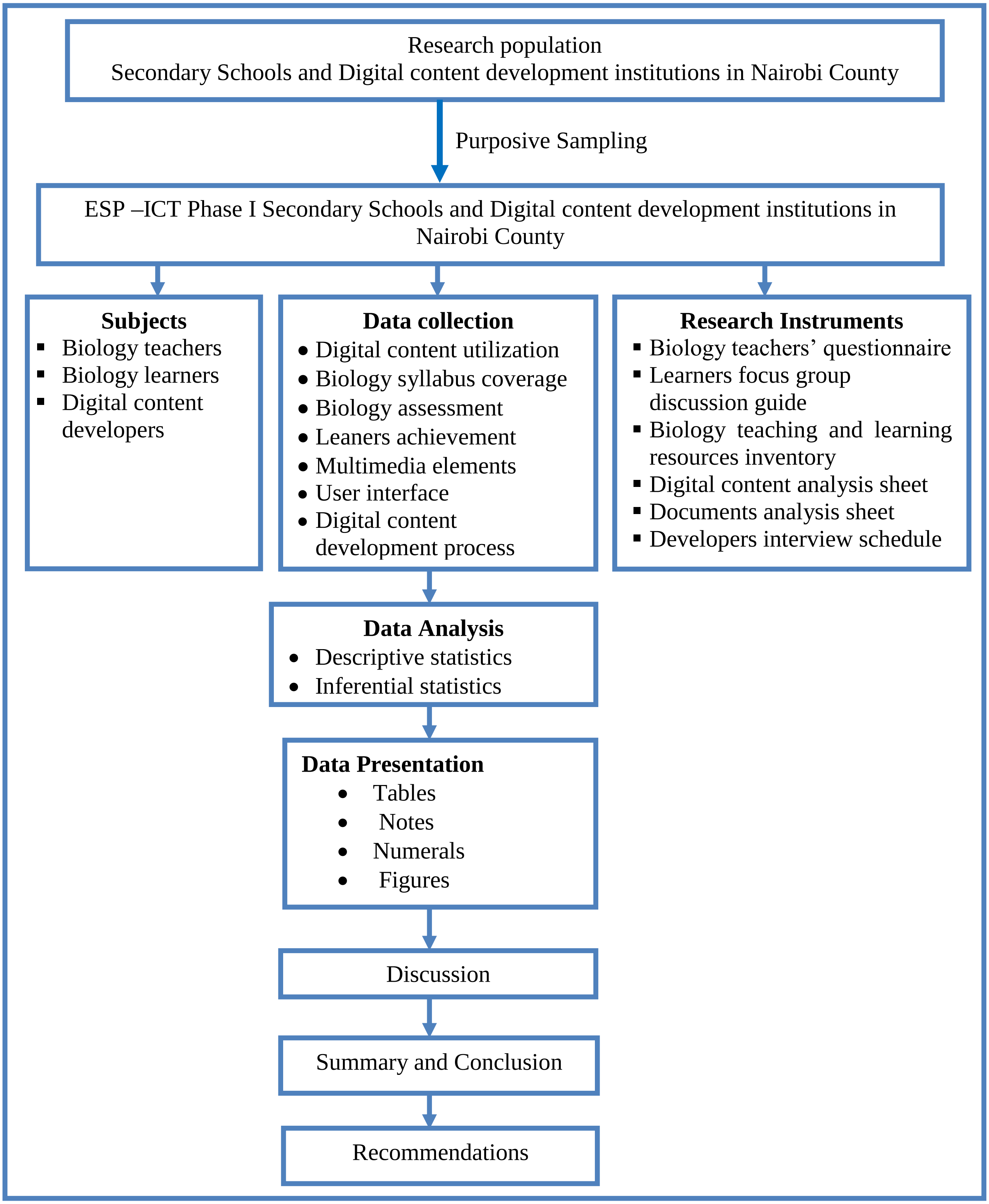

Figure 3.1: The Triangulation design for the study

3.3 Variables

A variable is a qualitative or quantitative unit which can take on diverse values or levels (Meredith, Borg and Gall, 1996). They are interrelating factors which bring about an outcome. Based on the conceptual frame work of this study, the independent variables were the utilization and design of curriculum digital content while the Biology instructional process was the dependent variable. The intervening variables were the learner, teacher and instructional resources. The factors under each variable are provided on table 3.1.

Table 3.1 Independent, intervening and dependent variables

Independent variables	**Intervening variable**	**Dependent variable**
Digital Content Utilization - Digital content access - Digital content use Digital Content Design - Multimedia elements - User interface	Learner - Learning ability - ICT skills Teacher - Qualification - Teaching experience - ICT skills Instructional Resources - Syllabus - Reference materials - Laboratory apparatus & materials	Biology Instructional Process - Syllabus coverage - Assessment mode - Achievement

3.4 Location of the study

This study was carried out in Nairobi County (Appendix viii). Nairobi County is one of the forty-seven Counties in Kenya. It is located in South-Central Kenya, 140 kilometres south of the equator. The County was founded in 2013 on the same boundaries as the former Nairobi Province, when Kenya's eight provinces were subdivided into forty-seven counties. This county was purposively selected because it is where most of the digital content developers are located. This would make it possible for the researcher to collect data on the digital content development process and the types of user interface used by the developers. Compared to other counties, schools within Nairobi are much more likely to be using digital content which was the key resource that was investigated in this study. This is because Nairobi, being an urban centre and capital city of the country, is likely to be more advanced in technology than other parts of the country.

3.5 Target population

A population refers to any group of institutions, people or objects that have common characteristics (Ogula, 2005). A target population of a study is the totality of persons, events, organizations, units or other sampling units which concern the research problem (Mohlokane, 2004). The target population for this study was secondary school Biology teachers and Form Three Biology learners drawn from fifteen ESP-ICT phase I secondary schools in Nairobi County. Digital content developers from two digital content development institutions in Nairobi county and whose Biology digital is approved by KICD were also targeted. Table 3.2 summarises the target population in this study.

Table 3.2: Target population for the study

Target Group	Total Number
Form 3 Biology learners in the selected 15 ESP-ICT Phase I Secondary Schools in Nairobi County	1,617
Biology teachers in the selected 15 ESP-ICT Phase I Secondary Schools in Nairobi County	68
Digital content developers in the 2 approved Biology digital content development institutions in Nairobi county	21
Total	1,706

From table 3.2, the target population for the study was 1, 706. Form Three Biology learners were selected for the study because they were likely to have interacted with digital content since the inception of the ESP-ICT project in 2010/2011. Biology teachers in these schools were also likely to have utilised digital content in their instructional process and were therefore considered appropriate for this study. Biology as a subject was selected since it is the area of specialization of the researcher while ESP-ICT schools had digital content which was the key aspect of investigation in this study. Only fifteen of the thirty-five ESP-ICT phase I schools (Appendix vii) were involved since the study was resource intensive. It would not have been possible to involve all the thirty-five schools owing to the cost and time required to cover them. Digital content developers were involved since the study also dealt with digital content design and deriving a model for the process of digital content development.

3.6 The Sampling Procedure and Sample size

Sampling is a process of selecting a number of individuals or objects from a population such that the selected group contains elements representative of the characteristics found in the entire group (Orodho and Kombo, 2002). Sampling is a procedure, process or technique of choosing a subgroup from a population to participate in the study (Ogula, 2005). It is the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected.

3.6.1 Sampling Procedure

Various sampling techniques were applied to come up with the required sample for this study. A sampling technique is the identification of the specific process by which the entities of the sample are selected (United States Bureau of the Census, 1998). This study employed both non-probability and probability sampling techniques to obtain the required sample size. In non-probability sampling, purposive technique of sampling was used. The researcher tries to make the sample representative, depending on his purpose, hence making the representation subjective in purposive sampling (Barreiro and Albandoz, 2001). On the other hand, probability sampling is the one in which each respondent has the same probability of being selected. Under probability sampling, stratified random sampling and simple random sampling techniques were employed.

3.6.1.1 Purposive sampling

Purposive sampling techniques involve selecting certain units or cases, based on a specific purpose (Tashakkori and Teddlie, 2003). This technique of sampling is essential when a researcher is studying a definite characteristic, feature or function. Purposive sampling is a technique in which, particular settings, persons, or events are deliberately selected for the important information they can provide that cannot be acquired from other choices (Maxwell, 1997). The researcher decides what needs to be known and looks for subjects who can provide the data by virtue of knowledge or experience (Bernard, 2002).

This study involved investigating the influence of the utilisation and design of curriculum digital content on the Biology instructional process. Purposive sampling technique was therefore used to select ESP ICT phase I schools, Form Three Biology learners, Biology teachers and digital content development institutions. ESP-ICT phase 1 secondary schools were selected using this technique since they had digital content which was a key resource required for this study. In addition, information on the design and utilisation of digital content could be obtained from these schools.

Form Three Biology learners were considered to be the most suitable for this study and therefore purposively sampled. This is because they have had adequate time to utilise and interact with the digital content since it was disseminated in the ESP-ICT phase I secondary schools in the year 2012 while they were in Form One. Form One and Two learners had interacted with the digital content for a shorter time while Form Four learners did not interact with the digital content while in Form One since the schools had not been provided with the digital content in 2011.

Since this study was based on Biology instruction, Biology teachers were also purposively chosen for data collection. For comparison purposes, it was important to purposively select a group of teachers who frequently utilised Biology digital content and another one that rarely or never utilised the content for instructional. Charles and Yu (2007) argued that purposive sampling may be used to achieve comparability across different types of cases on a dimension of interest.

Digital content design and development data was also required for this study. This is because the study needed to derive a model on digital content development process in addition to obtaining information on the current digital content design. This data could only have been obtained from Institutions with Biology digital content that was approved by MoEST through KICD. There was only one digital content development institution with approved Biology digital content in addition to Kenya Institute of Curriculum Development (KICD) which is the national curriculum development centre. These two institutions were therefore purposively sampled for this study.

3.6.1.2 Stratified random sampling

This is a probability sampling technique whereby the researcher divides the entire population into different subgroups or strata then randomly selects the final subjects proportionally from different strata (Barreiro and Albandoz, 2001). The subgroups are based on various aspects such as geographical location, gender, performance or age. Stratified random sampling involves dividing the population into homogenous subgroups and then taking a simple random sample in each subgroup (Kombo and Tromp, 2006). This technique was used to subdivide Nairobi county into eight geographical regions based on the eight constituencies that existed in 2011/2012 when ESP-ICT phase I was implemented. Two schools were then randomly selected from each of the seven constituencies while the only ESP-ICT school in the eighth constituency was also selected. A total of fifteen ESP-ICT phase I secondary schools in Nairobi county were therefore selected for this study. Selection of fifteen ESP-ICT phase I secondary schools in Nairobi was necessitated by the limited resources available for study since this research was privately funded.

Further, the technique was used to subdivide the Form Three learners into two groups, that is, a group that frequently utilised Biology digital content and another one that rarely or never utilised the content for instruction. Some learners utilised curriculum digital content frequently while others rarely or never utilised it for instruction since the Biology digital content available in schools was mainly general reference and revision material. From the analysis done in this study, most of the study schools did not have course digital content which is normally more appropriate for lesson delivery since it covers the whole syllabus in the required depth. While general reference materials do not cover the entire syllabus, revision materials are normally shallow and do not develop concepts and skills as required. They are thus not preferred for syllabus coverage. This implies that even learners and teachers who utilised Biology digital content frequently used it to complement other teaching and learning resources.

Ten learners were then randomly selected from each stratum to form Group A and Group B. Thus, twenty learners were involved in every sample school due the limited resources available for the study. Involving all the Form Three learners in the study schools would have resulted to having too many groups of guided discussion. Many groups would have been difficult for the researcher to handle effectively with the available time and resources. Both groups were selected from the same schools since data that were used for comparison in syllabus coverage and learners achievement were obtained from records of work and progress records. Records of work and progress records for the six school terms, that is, term III in Form One to term II in Form Three had already been filled in Form Three term III when collection of data for this study took place. In this regard, the data could not have been influenced by the study or presence of the researcher during the data collection process.

3.6.1.3 Simple random sampling

In this type of sampling, each unit in the accessible population has an equal chance of being included in the sample, and the probability of a unit being selected is not affected by the selection of other units from the accessible population (Charles and Yu**,** 2007). Cohen, Marion and Morrison (2011) highlighted that a simple random sample is a subset of a target population in which each member of the subset has an equal chance of being selected. In this study, simple random sampling was used to select digital content developers from digital content development institutions with approved Biology content in Nairobi county. This technique was chosen because the target population which included digital content developers was homogenous in nature.

3.6. 2 Sample Size

A sample is a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1995). A sample size of between ten to twenty percent is generally ideal for study (Amedahe, 2002; Aryl, Jacobs and Rozavieh, 2002). Mugenda and Mugenda (2003) also noted that a sample size of ten to fifty percent is acceptable in research. This suggests that a sample size of at least ten percent is ideal for a study. Considering the experts view in addition to the nature of the accessible population and available resources, a proportionate sample size of 300 Form Three Biology learners, 30 Biology teachers and 10 digital content developers was used for this study. Table 3.3 shows a summary of the sample size used in this study.

Table 3.3: Sampling matrix

Population Description	Target Population	Sample Size	Sample Size Percentage
Form 3 Biology Learners (Group A and B)	1,617	300	18.6%
Biology Teachers	68	30	44.1%
Digital content Developers	21	10	47.6%

From table 3.3, the sampled Form Three Biology learners formed 18.6% while sampled teachers accounted for 44.1% of the target population. In addition, the sample size of the selected digital content developers was 47.6% of the targeted population. These percentages meet the recommended percentage of ten percent in statistical terms (Orodho and Kombo, 2002).

3.7 Research instruments

Six instruments were used in this study, namely:

- Biology Teachers Questionnaire
- Learners Focus Group Discussion Guide
- Biology Teaching and Learning Resources Inventory

- Digital Content Analysis Sheet
- Documents Analysis Sheet
- Digital Content Developers Interview Schedule

3.7.1 Biology Teacher Questionnaire

Biology Teacher Questionnaire (Appendix i) was used to gather data from Biology teachers in the study schools. Through these questionnaires, the researcher sought to find out the following: -

- Whether teachers accessed and utilised digital content in the Biology instructional process.
- Devices and formats by which teachers accessed and utilised Biology digital content in schools.
- Teachers' opinion on the usefulness of digital content in terms of syllabus coverage, learners' assessment and achievement in Biology.
- Their preference regarding digital content user interface and the different elements for Biology instruction.

3.7.2 Learners Focus Group Discussion Guide

This instrument (Appendix ii) was used to gather data from the learners in the study schools during the focused group discussions. Among the information that was collected using this instrument is the devices and the formats in which learners' access and utilize Biology digital content. In addition, learners were asked to give their preference in terms of different user interface and multimedia elements used in the digital content. Moreover, the focused group discussion was used to seek learners' opinion on the influence of digital content on their conceptualization of Biology concepts and consequently achievement. These discussions also enabled the researcher to find out the challenges the learners encounter in the access and utilisation of digital content and their proposed interventions that can help improve the situation. The study also sought to find out whether there was any change in terms of test items, frequency of assessment and the time taken to get feedback from assessments.

3.7.3 Biology Teaching and Learning Resources Inventory

The Biology teaching and learning resources inventory (Appendix iii) was used to take stock of the ICT devices, accessories and peripherals that are used by the school to access and utilize digital content. Among the things that were recorded were the internet, intranet connectivity and devices such as computers, mobile devices, projectors, smart boards, digital televisions, set top boxes and tablets. In addition, storage facilities such as external hard disks, flash disks, memory cards, CDs and DVDs were listed. Moreover, the researcher observed whether the schools had readily available digital content for use in Biology instruction.

3.7.4 Digital Content Analysis Sheet

This instrument (Appendix iv) was used to analyse the Biology digital content available in secondary schools in terms of their multimedia elements and user interfaces. These were then compared with the teachers and learners' views and preferences. This information played a role in coming up with a model for development of Biology digital content.

3.7.5 Documents Analysis Sheet

Documents analysis sheet (Appendix v) was used to analyse various Biology professional documents in the study schools. Among the documents that were analysed included teachers' records of work, progress records and learners' notes. The main aim for this analysis was to establish the syllabus coverage and learners' achievement in Biology. Using the records of work and learners' notes, the number of covered and uncovered topics in Biology was recorded. Using the total number of Biology topics indicated in the syllabus, a percentage of syllabus coverage was calculated. A comparison of syllabus coverage was then done between those groups that utilize digital content and the ones that do not utilize the content. Using the progress records, learners' achievement from six assessment tests that is, end of term III in Form One, end of term I, II & III in Form Two and end of term I & II in Form Three were recorded. The scores were then categorized into two groups, that is, the group of the learners who use digital content in their studies and the ones who do not use the content depending on the information given by teachers on the questionnaire and learners during the discussion. A comparison of the means was then done using a t-test to find out whether there was any statistically significant difference between the scores of the learners who utilize digital content and the ones who do not use it.

3.7.6 Developers Interview Schedule

This instrument (Appendix vi) was used to gather data from the digital content developers in Nairobi County. Some of the information collected includes the process followed by the different developers to develop digital content, multimedia elements they included and the user interface in their content. In addition, information on who was involved in the process of development of digital content was also recorded. Developers were also asked to make suggestions that would make the development process better leading to production of higher quality content.

3.8 Pilot study

The pilot study was used mainly for the validation and testing of the reliability of the instruments that were used in the study. According to Kombo and Tromp (2006), a pre-test of the questionnaire and other field instruments is one confident way the researcher can find out if everything works. One ESP-ICT phase I secondary school and one digital content development institution in Nairobi County which were not sampled for the main study were involved in pilot testing of the instruments. The school and the digital content development institution were selected by simple random sampling from the ESP-ICT phase I secondary schools and content development institutions in Nairobi.

3.8.1 Reliability of instruments

Test for the reliability of the instruments was done using the test-retest method. The selected school was visited and after getting permission from the principal, two Form Three Biology teachers were requested to fill the questionnaire. The researcher then had a discussion with two groups of learners selected randomly from the Form Three classes. The groups were selected by first dividing the Form Three learners into two groups based on digital content utilisation. Ten learners were selected randomly from the group that utilised Biology digital content frequently in their studies to form Group A. The other ten learners were randomly selected from the group that rarely or never used Biology digital content in their studies to form Group B.

ICT devices and accessories that were used by the schools to access and utilize digital content were recorded using the Biology teaching and learning resources inventory while the scores of the learners for the Biology tests done at the end of term III in Form One, term I, II and III in Form Two and term I & II in Form Three were recorded using the documents analysis sheet. In addition, documents such as records of work and learners' notes were analysed using the documents analysis sheet while digital content available in the schools was analysed and recorded using the digital content analyses sheet.

Finally, one digital content development institution which was not involved in the main study in Nairobi County was visited and the content developers interviewed and their views recorded using the interview schedule. This process was repeated again in the same institutions after two weeks. The pilot data was organised and a correlation between the first and the second pilot data done using the Pearson product-moment correlation coefficient to ascertain the reliability of the instruments. The values yielded by each instrument were as shown on table 3.4.

Table 3.4: Research instruments correlation values

	Research Instruments	Correlation values
1	Biology Teachers Questionnaire	0.88
2	Learners focus group discussion guide	0.89
3	Biology teaching and learning resources inventory	0.94
4	Digital content analysis sheet	0.96
5	Documents analysis sheet	0.99
6	Digital content developers interview schedule	0.81

All the instruments had correlation values that were greater than 0.7 between the two administrations done during piloting. This was an indication of a strong correlation between the data collected in the first and second round of piloting. It was therefore concluded that the instruments were reliable and could be used for the intended study.

3.8.2 Validity of Instruments

Content validation is a process whose goal is to provide a guarantee that an instrument measures the content area it is expected to measure (Frank-Stromberg and Olsen, 2004). To ensure content validity, the instruments in this study were first discussed with the two supervisors to ascertain that they were well formulated. The validity of the instruments was then established using Lawshe's content validity ratio formula

(Lawshe, 1975). This formula has been commonly used to establish and quantify content validity in various fields such as education, personnel psychology, organizational development, health care, and market research (Wilson, Pan, and Schumsky, 2012).

In this case, five panellists were selected from experienced content designers and researchers. The panellists went through each item in all the instruments indicating whether it was essential, useful but not essential or not necessary to performance of the construct.

The formula CVR= (n_e - N/2) / (N/2) was used where:

- CVR = content validity ratio
- n_e = number of SME panellists indicating essential
- N = total number of SME panellists was involved.

This formula yields values that range from -1 to +1 where positive values indicate that at least half of the SME panellists rated the item as essential while values less than 0.9 show a weak correlation ratio. The mean CVR across all the items in Biology teaching and learning resources, documents analysis sheet and digital content analysis sheet were 0.96, 0.93 and 0.95 respectively. In Biology teachers' questionnaire, Learners focus group guide and the digital content developers' interview schedule, the mean CVR values were less than 0.9 at first indicating a weak content validity ratio. However, all the values were positive meaning at least half of the SMEs rated each item as essential. Lawshe (1975) proposed that based on recognised psychophysical principles, a level of 50% agreement gives some guarantee of content validity. The instruments with a CVR of less than 0.9 were then adjusted based on the information given by the panel of experts. This raised their CVR values to 0.97, 0.94 and 0.92 respectively.

3.9 Data Collection Procedure

In this study, data was collected using both online and offline modes. For the offline mode, instruments were printed and data collected using hand copies while on the online mode, soft copies were used to collect data from respondents who could not be reached physically. This was achieved by emailing some of the questionnaires while in some cases telephony interviews were done. All this was aimed at achieving maximum response during this study. Data were first collected from the study secondary schools in the first phase and then the digital content development institutions in Nairobi county for the second phase. Before embarking on the data collection process, the researcher obtained permission from National Commission of Science, Technology and Innovation, Nairobi County Commissioner and Nairobi County Director of Education.

During the first phase, study schools were visited and permission obtained from the school principals. The researcher then met with the Biology teachers, explained to them about the study and assured them about the confidentiality of the information that they were going to provide. Two Biology teachers were then sampled purposively and requested to fill the Biology teachers' questionnaire. They gave information on the utilisation of curriculum digital content and how it influenced the Biology instructional process. They also gave information on the content design including multimedia elements and user interfaces of the Biology digital content they accessed and or utilised.

In addition, they gave their view on the preferred multimedia elements as well as user interfaces.

Guided focus group discussion then took place with learners in Group A and B separately. The two groups of learners were selected and placed in groups through stratified random sampling. The learners were probed to give information on digital content utilisation in Biology. In addition, they were explored on the influence of digital content utilisation on their assessment and achievement in Biology. Learners were also asked questions pertaining the design of the digital content they utilised. Some of these questions focused on the interface elements such as the navigational tools and content layout in terms of the voiceovers, graphics and text. In addition, learners were requested to provide information about the multimedia elements in the digital content they utilised. They were also requested to give their preferred multimedia elements while giving reasons for their answers.

The infrastructure that facilitates access and utilisation of digital content in each school was assessed and recorded using the Biology teaching and learning resources inventory. This assessment mainly focused on the availability of e-learning laboratories, connectivity, devices such as computer and storage devices such as external hard disks and DVDs. Digital content design in the schools was then analysed using the digital content analyses sheets to determine their UI and its multimedia elements. In addition, the learners' scores for end of term Biology tests for term III in Form One, term I, II & III in Form Two and term I & II in Form Three were recorded using the documents analysis sheet. These were used to compare Biology achievement of learners who frequently used digital content and the ones who rarely or never used the content for instruction. Information from documents such as records of work and learners' notes was also recorded using the documents analysis sheet. These data were used to compare syllabus coverage when digital content is frequently used and when it is rarely or not used at all for instruction.

During the second phase of the study, the researcher visited the sampled digital content developers within Nairobi county. Permission was first obtained from the chief executive officers of the digital content development institutions. The researcher then met with the digital content developers, explained to them about the study and assured them of the confidentiality of the information that they were going to provide. Five digital content developers were then randomly sampled for interview since this group was homogenous. The developers were interviewed (appendix vi) on the process and procedures they follow in digital content development. They also gave information on the persons involved in the content development, UI as well as multimedia elements in their digital content. In addition, developers were requested to give suggestions on a possible model that they think would lead to development of high quality digital content with a standard user friendly interface.

3.10 Data analysis and presentation

The collected data was collated and coded based on the main study themes before it was analysed. Since both qualitative and quantitative data had been collected, analysis involved both descriptive and inferential statistics. To establish how learners and teachers accessed and utilised Biology digital content, data obtained through Biology teacher questionnaire, Learners focus group discussion guide, Biology teaching and learning resources inventory and Digital content analysis sheet was grouped, organized and summarized in notes, tables, percentages and graphical presentations. This data also enabled the researcher to examine the multimedia elements and user interfaces in the Biology digital content and establish their influence on the Biology instruction process.

Data collected using documents analysis sheet were analysed using means and then t-test and presented in tables and numerals. This helped the study to find out whether there was any statistically significant difference in syllabus coverage between groups that use digital content and the ones that did not use the content in Biology instruction. It also enabled the researcher to find out whether there was any statistically significant difference between the achievement of learners who use digital content and the ones who do not use the content in Biology. Subsequently, it was possible to tell whether the utilisation of curriculum digital content has influence on the Biology instructional process.

To device a model that can guide development of appropriate digital content for Biology curriculum, data obtained through the digital content developers' interview schedule were analysed, organized and presented in notes, percentages and graphics. Information on the stages of curriculum digital content development by various developers, resources involved and the challenges encountered was acquired from this data. Statistical package for social sciences (SPSS) version 20.0 facilitated the process of analysis.

3.11 Logistical and ethical considerations

After official clearance by Graduate School, Kenyatta University, the researcher obtained authorization and permit to conduct this study from the National Commission of Science, Technology and Innovation (NACOSTI). This is a government agency in the Ministry of Education, Science and Technology (MoEST) in Kenya. He then reported to the County Commissioner and County Director of Education (CDE) – Nairobi. Thereafter, sampled schools and digital content development institutions were visited to determine the workability of the scheduled activities. After meeting the principals of the study schools, the researcher then met Biology teachers where basic issues about the research and its benefits were discussed.

Teachers were requested to explain to their students about the study since in some cases it affected their normal learning programmes. Finally, the researcher met the sampled digital content developers in Nairobi County and discussed various issues concerning this study and made arrangements on the way interviews were to be conducted. The process of data collection was then carried beginning with piloting of the study instruments that was later followed by the actual data collection. All the information collected from the respondents was treated confidentially and was not shared with any other person or utilised for any other purpose apart from the objectives for this study. The chapter that follows details the analysis and presentation of the findings as per the purpose of the study.

CHAPTER FOUR

PRESENTATION OF FINDINGS, INTERPRETATION AND DISCUSSION

4.1 Introduction

The purpose of this study was to investigate the influence of the utilisation and design of curriculum digital content on the Biology instructional process among secondary schools in Nairobi county, Kenya. In specific, the study sought to:

a) To establish secondary school learners' and teachers' utilisation of curriculum digital content in the Biology instructional process.

b) To determine whether utilisation of secondary school curriculum digital content influences the Biology instructional process.

c) To analyse the nature, and influence of multimedia elements in secondary school curriculum digital content on the Biology instructional process.

d) To examine the formulation, and influence of user interface in the secondary school curriculum digital content on the Biology instructional process.

e) To derive a model that can guide the design and development of an effective digital content for secondary school Biology curriculum.

This chapter presents the findings of the study, interpretation and discussion. The results are presented in various main themes which are further considered in subheadings guided by the objectives of the study. The main themes are: General and demographic information of the teachers, learners and schools involved in the study, Teachers and learners' utilisation of curriculum digital content in the Biology instructional process, influence of curriculum digital content utilisation on the Biology instructional process, Nature and influence of curriculum digital content multimedia elements on the Biology instructional process, formulation and influence of curriculum digital content user interfaces on Biology instructional process and deriving a model for design and development of an effective Biology digital content.

4.2 General and demographic information of the teachers, learners and study schools

The main objective of this study was to investigate the influence of the utilisation and design of curriculum digital content on the Biology instructional process among secondary schools in Nairobi county, Kenya. As such, teachers, learners and schools were all very critical in providing data utilisation and design of the curriculum digital content. This section therefore attempts to give the general and demographic information about these key pillars of the study. More specifically, the characteristics of teachers, learners and ICT integration tools in the study schools were considered. Understanding this information was essential since it had the potential of influencing the findings of the study. Data for this section were collected using the questionnaire for Biology teachers, learners' focus group discussion guide and the teaching and learning resources inventory.

The study involved Biology teachers teaching Form the subject in the sample schools in Nairobi county. In terms of academic qualifications, majority of the teachers (66.7%) had a degree in science education while 23.3% had a diploma in science education. Only 10% had a master's degree in education. The bulk of the teachers (76.7%) in this study had basic ICT skills while 16.7% had advanced ICT skills. It is only 6.7% of the teachers that did not have ICT skills at all. The teachers had relevant teaching experience with at least three quarters of them (76.7%) having taught Biology for more than 5 years. Figure 4.1 summarises the teaching experience of the teachers involved in this study.

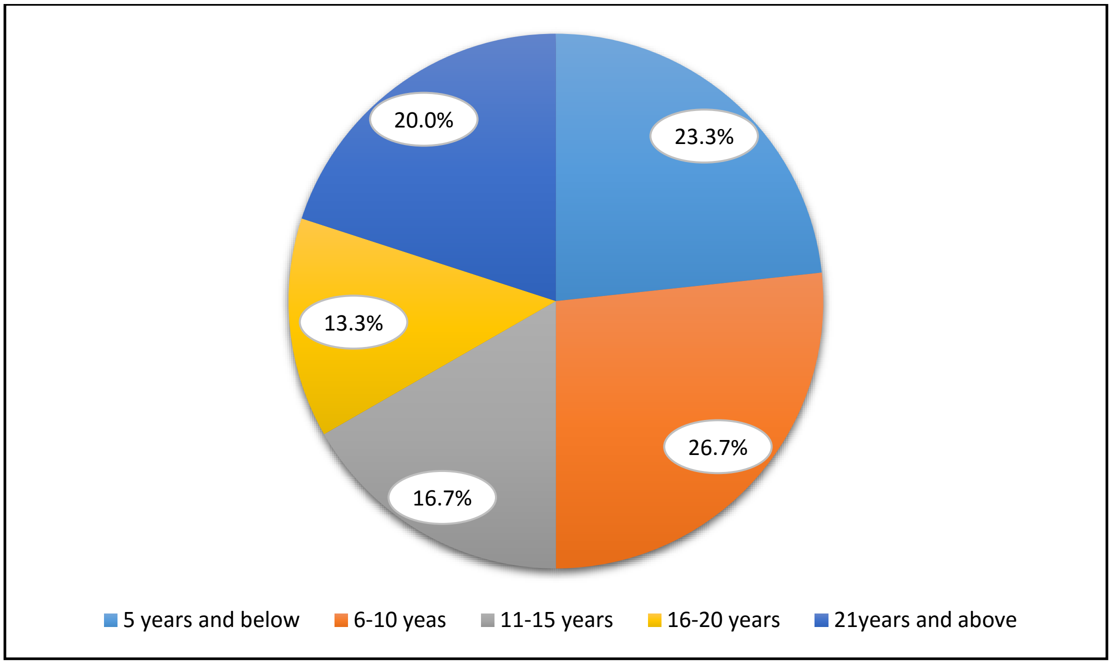

Figure 4.1: Teaching experience of the teachers involved in the study

These findings mean that the study involved a majority of teachers who had the relevant academic qualifications, teaching experience and ICT skills. It can be concluded therefore that majority of the teachers involved in this study had the necessary pedagogical and technological skills that would have enabled them to access and utilize Biology digital content in the instructional process. Teachers academic qualifications, teaching experience and ICT skills which were among the extraneous factors are therefore not likely to have affected this study significantly since they were moderated.

All the learners involved in the study were in Form Three level taking Biology. This therefore means that they were of relatively same ability and age. Majority of them (90%) had ICT skills that would have enabled them to access and utilize Biology digital content. Only 10% of the learners involved in this study did not have ICT skills at all. Consequently, most of the learners could have been able to access and utilize Biology digital content on their own if provided with the appropriate content and the necessary infrastructure such as ICT devices and connectivity.

Biology teaching and learning resources available in the study schools were also considered and recorded using a teaching and learning resources inventory. It was confirmed that all the study schools had basic teaching and learning resources required in Biology including reference materials such as the syllabus and text books, science laboratories, apparatus and practical materials. This suggests that the schools were of relatively the same level in terms of resources. In addition, they were well equipped in terms of ICT infrastructure. All the schools had ICT integration laboratories with majority of them (87%) connected to internet. This means that most of the study schools had free access to online open source digital content. Moreover, most of the schools (93%) had digital content in computer-based formats ranging from course digital content to revision content. They also had content storage devices including flash disks, DVDs and CDs. Table 4.1 summarises the percentage of schools with various ICT resources and infrastructure.

Table 4.1: ICT infrastructure and resources in the study schools

Content access devices			Content storage devices		
S/N	Device	% of schools	S/N	Device	% of schools
1	Computers	87	1	External hard disks	33
2	Mobile devices	93	2	Flash disks	67
3	Digital televisions	27	3	DVDs	87
			4	CDs	53
			5	Memory cards	7
School connectivity			**Computer based digital content**		
S/N	Type	% of schools	S/N	Type	% of schools
1	Internet	87	1	Course	13
2	Intranet (LAN)	47	2	General reference	93
			2	Revision	87

All the study schools were therefore considerably within the same range in terms of teaching and learning resources, ICT infrastructure and availability of digital content. These factors therefore would not have affected the access and utilisation of Biology digital content by teachers and learners. It can thus be concluded that any difference in access and utilisation of Biology digital content between the study groups would have resulted from other factors such as content design and dissemination modes. In addition, the difference in the various aspects of the Biology instructional process such as the syllabus coverage, assessment and achievement are likely to have emanated from digital content utilisation since factors like teachers' characteristics, learners' characteristics and the teaching and learning resources were harmonized across the study schools.

4.3 Teachers and learners' utilisation of curriculum digital content in the Biology instructional process

One of the specific objectives of this study was to investigate secondary school teachers and learners' utilisation of the Biology digital content. To do this, it was crucial to consider various aspects that relate to teachers and learners' access to, and use of the Biology digital content. This section hence focused on finding out if teachers and learners actually accessed and used Biology digital content in the instructional process. To examine this, various digital content utilisation factors were considered. These include access and use of the Biology digital content in the instructional process, Areas of utilisation of Biology digital in the instructional process, formats in which the content was accessed, preferred formats of access, devices used to access the content and devices used for storage of the content.

4.3.1 Access and use of Biology digital content

Teachers were asked to indicate whether they accessed and used Biology digital content in the instructional process. Majority of the teachers (80%) in the study schools indicated that they had accessed Biology digital content. However, only 56.7% had utilised the content in the instructional process. This means that 23.3% of the 80% of teachers, who had accessed Biology digital content, rarely or never used it for instructional purposes. This was a disconcerting scenario considering that we are in a knowledge based society that requires use of technology for better instruction yet teachers could access digital content and not use it for instructional purposes.

In addition, 20% of the Biology teachers involved in the study had not accessed and hence never utilised Biology digital content for instructional purpose. Consequently, 43.3% of the teachers in the study schools had not or rarely utilised Biology digital content for instructional purposes. This is an alarming figure considering that these teachers were sampled from ESP-ICT phase one schools that had the necessary ICT infrastructure for access and utilisation of digital content for instruction since the year 2011.

An assessment of the study schools revealed that they had ICT integration laboratories, connectivity, access and utilisation devices such as computers, LCD projectors, external hard disks and even digital content packaged in computer based formats. Nonetheless, some teachers did not use the digital content for Biology instruction. Asked why they could not utilise digital content for Biology instruction, the teachers gave the following reasons:

- Biology digital content was not available for use. This is because it was locked in the school administrators' offices and long procedures set for anyone to access it.
- The available content was difficult to navigate and therefore required a lot of time to utilize. This time is not available considering the amount of content that needs to be covered as outlined by the Biology syllabus.

- The provided content was shallow and could not be used for teaching since Biology concepts were not covered as outlined in the syllabus.
- Some of the content was not relevant to the current Biology syllabus and therefore may end up misleading the learners.
- Some of the content provided is either not compatible with the computers in the schools or required very high specifications since the computers kept on hanging while using the content.

On the other hand, the sampled learners had an equal level of utilisation and non-utilisation (50%) levels since they had been selected through stratified random sampling to enable comparison of the two groups in terms of their achievement. During the focus group discussions, learners who rarely or never utilised Biology digital content for instruction were probed on their reasons for non-utilisation. They gave various reasons including the following:

- Digital content was not available for use because it was locked in the administrators' and teachers' offices or learners were not allowed into the e-learning laboratories.
- It was not easy to navigate through the available digital content and therefore learners felt use of the content took a lot of their study time.
- Lack of ICT devices such as tablets and other mobile devices that could be used to access online digital content.
- Failure by their teachers to expose them to the digital content during Biology lessons.

Although teachers and learners gave various reasons for not utilising curriculum digital content for Biology instruction, Galanouli, Murphy and Gardner (2004), observed that not all teachers are normally convinced that ICT should be an integral part of their teaching strategies. KICD (2013) indicated that only 38% of the ESP-ICT schools in Kenya were utilising the Institutes Biology digital content. This was despite the fact all these schools had been provided with the Biology digital content from the Institute. This scenario is not unique to Kenyan schools only. Šorgo, Verčkovnik and Kocijančič (2010), observed that about two-thirds of Slovene secondary schools received computers equipped with data loggers and sensors to be used in teaching Physics, Chemistry and Biology. Later it was found out that only a couple of Biology teachers were using these digital resources in their classrooms or laboratories.

Both teachers and learners had almost similar concerns for non-utilisation in this study. One of the key reasons was non-availability of the digital content to utilize despite the fact that all the study schools had been provided with digital content by the ministry of education through KICD. They indicated that the computer-based digital content was available in the schools but was locked in the school administrators' offices and accessing it required a long process that was time consuming. Though most of the schools had internet connectivity where they could access online content, the computers and other digital devices were also locked in ICT integration centres and computer laboratories. These rooms were not easily accessible to learners and teachers. These factors made it difficult for the learners and teachers to access and utilize the digital content for instruction.

In his paper, Technology Leadership and ICT Use, Mwawasi (2014), found out that school leaders facilitated increased access to ICT facilities to the teachers and supported them, alongside training, to enable them explore various ways of integrating ICT in teaching and learning. Yuen et al (2003) observed that that the strategy adopted by a school in instituting such a change as ICT integration and the resulting variation of pedagogical practices due to its application is strongly dependent on the school leaders' vision and understanding of the role and influence. This perhaps suggests that schools' leaders need to be fully involved in the various stages of ICT integration in teaching and learning to ensure its successful implementation. This may call for an all-inclusive ICT integration model including digital content development, dissemination and utilisation process. This would ensure that teachers, school leaders and other stakeholders are involved in the whole process. They would therefore understand the importance, what, when and how digital content should be integrated in teaching and learning to benefit the learners. As a result, school leaders would ensure that digital content was easily accessible by the teachers and the learners for utilisation in the instructional process.

Another reason common to both teachers and learners is the difficulty in navigating through the available digital content. Teachers and learners felt that it was not easy to navigate through the available digital content and thus a lot of time was required for them to be able to access and utilize the content in teaching and learning. This implies that the interface of the available content was organised in such a way that it was not easy to navigate, locate navigation buttons or even the buttons were not available. Navigational tools are very important in the access and manipulation of any digital content. If the tools are not availed or not clearly placed on the content such that they can easily be accessed, then the utilisation of such content may be difficult. This may perhaps require more time to access and utilize the digital content.

Teachers and learners have a curriculum to cover within a limited period of time and therefore could be easily discouraged by a complicated digital content interface. Developers of curriculum digital content therefore need to ensure that navigation of the content is easy. Jisc digital Media (2013) pointed out that digital content interface should be designed in such a way that when using the content, it is always clear where you are and where you can go next. The user needs to be fully in control of their navigation and use of the content.

4.3.2 Areas of utilisation of Biology digital content in the instructional process

The study examined how teachers and learners used Biology digital content in the instructional process. Both teachers and learners indicated that they used Biology digital content in various ways. Some of the areas that teachers utilised digital content included preparing lessons, revising with learners, delivering content during the lessons and assessment of learners. A larger percentage (22.2%) of teachers used digital content for revision with learners as compared to other purposes such as content delivery (11.1%), assessment (11.1%) and preparation of lessons (5.6%). Most teachers (50%) utilised the content for a combination of purposes namely preparing lessons, content delivery, assessment and revision. The different ways in which digital content was used by teachers in the Biology instructional process are summarised on figure 4.2.

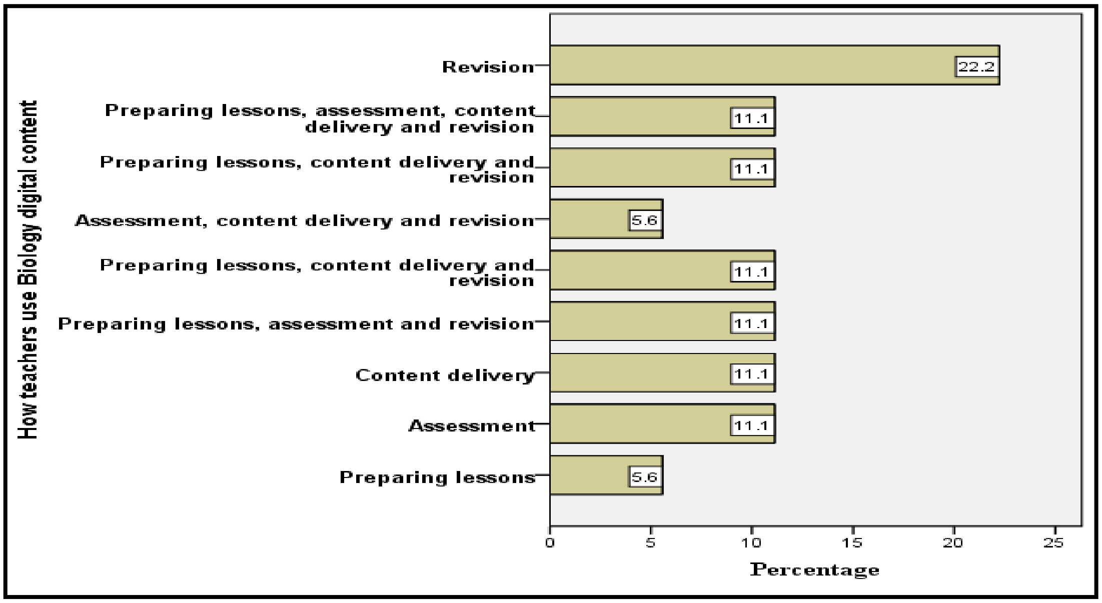

Figure 4.2: Use of Biology digital content by teachers

On the other hand, learners made use of the content in personal studies, revision, handling assignments and for general knowledge. The highest number of learners (26.7%) indicated that they used digital content for a combination of personal studies, revision and handling assignments. The various areas where learners applied digital content are summarised on figure 4.3.

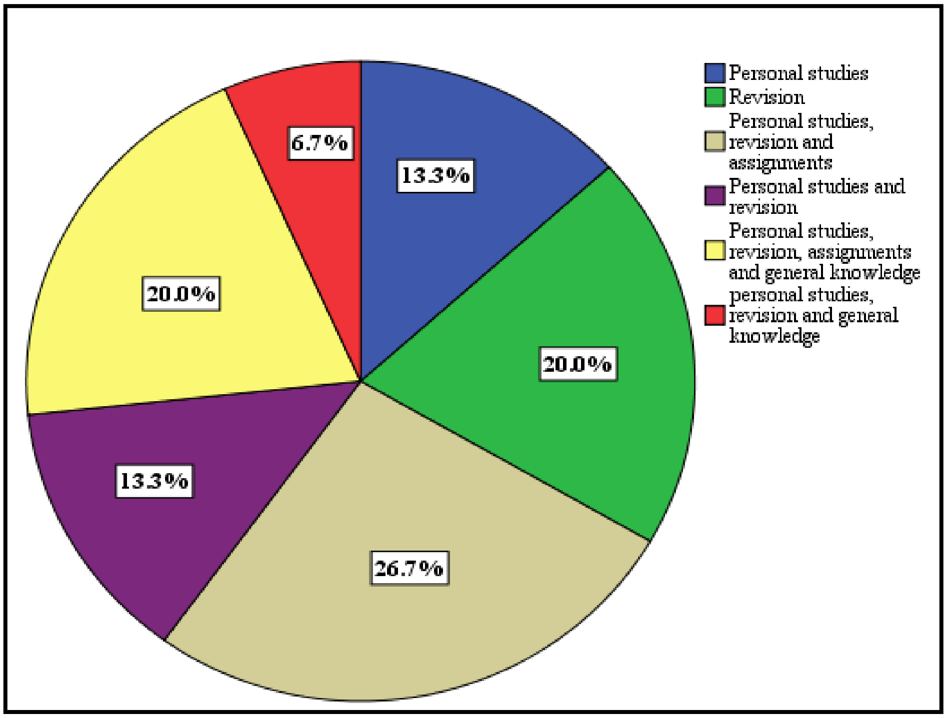

Figure 4.3: Use of Biology digital content by learners

From the findings on the content utilisation by both teachers and learners, it can be observed that 22.2% of teachers utilised Biology digital content for revision only while another 50% of the teachers utilised the content for a combination of purposes including revision with learners. It can therefore be generalised that 72.2% of the teachers utilised the digital content for revision with learners. The findings further showed that 5.6% of the teachers utilised the Biology digital content for lesson preparation only while another 50% used it for lesson preparation and a combination of other purposes. About 55.6% of the teachers therefore utilised the Biology digital content for preparation of their lessons. A further 11.1% of the teachers incorporated Biology digital content in their lesson delivery while 38.9% used the digital content for various other purposes in addition to lesson delivery. In total, about 50% of the teachers utilised the digital content for lesson delivery. Table 4.2 gives a general summary of how teachers and learners used the Biology digital content.

Table 4.2: Summary of the use of Biology digital content by teachers and learners

Use of digital content by teachers (n=17)	General percentage (%)	Actual percentage (%)	Use of digital content by learners (n=150**)**	General percentage (%)	Actual percentage (%)
Lesson preparation	50.0	23.7	Personal studies	80	30.4
Learners assessment	38.9	18.4	Personal revision	86.7	37.7
Content delivery	50.0	23.7	Handling assignments	46.7	20.3
Revision with learners	72.2	34.2	General knowledge	26.7	11.6
Total	211.1	100	Total	240.1	100

Generally, it can be observed that more teachers and learners used the Biology digital content for revision than any other purpose. This is most likely option because of the type of digital content available in the schools. An assessment of the types of digital content in the study schools revealed that 87% and 93% of them had revision and general reference Biology digital content respectively. These two types of digital content are preferred for revision as opposed to other instructional purposes. This is because while revision content is shallow and mainly concentrates on revision work, general reference materials do not cover the entire syllabus. Only 13% of the study schools had course digital content which is appropriate for preparation of lessons and content delivery since it covers the entire syllabus in the appropriate depth.

This kind of scenario affects various aspects of the instructional process such as syllabus coverage, assessment of the learners and the achievement of the learners in the assessment tests. If most teachers and learners utilize digital content for revision purposes, then learners understand the concepts better during revision time and consequently get better scores in the Biology assessment tests. Allen (1998) established that learners who used multimedia content were better in terms of academic achievement and knowledge retention as compared to their counterparts who studied using the traditional methods. Similarly, utilisation of digital content in assessment of learners improves various aspects of Biology assessment such as methods of assessment and duration of giving feedback to the learners. These kinds of positive influences on the instructional process due to utilisation of digital content may only be realised if the appropriate digital content in terms of multimedia elements and the user interface is employed.

4.3.3 Digital content access formats

Digital content comes in two main formats namely web-based and computer-based format. Web-based formats include websites, education portals and content developed on learning management systems and is mainly online while computer-based formats include CDs, DVDs, content and software installed on computers and servers and is mostly disseminated offline (Ministry of Education, 2011). Curriculum digital content format is very important since it determines how the content is accessed for use in the instructional process. This study therefore sought to find out the format of the content that had been utilized by the teachers and learners in the instructional process.

Teachers who indicated that they had accessed Biology digital content were asked to specify their access formats. Most of them (53.32%) said that they had accessed computer-based content while only 19.87% had accessed web-based digital content. Some teachers (26.81%) recorded that they had interacted with Biology digital content in both computer-based and web-based formats. This is summarised on figure 4.4.

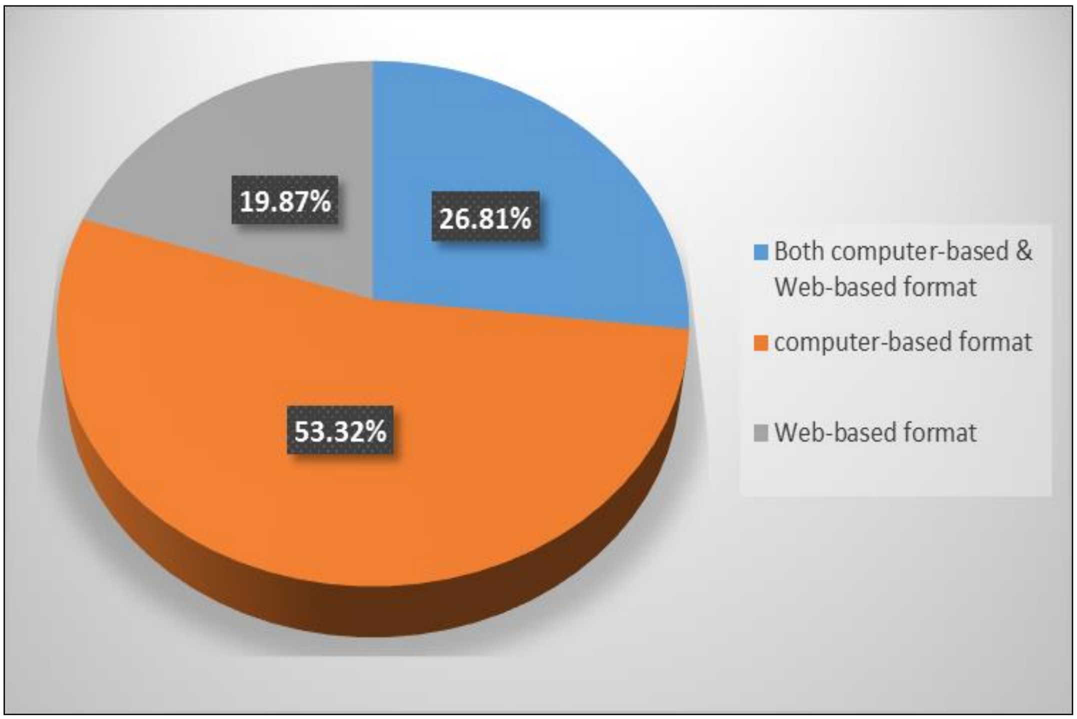

Figure 4.4: Teachers' digital content access formats

On the other hand, learners were probed on their digital content access formats during the focus group discussions. Slightly more than a half of them (52.91%) indicated that they had accessed computer-based digital content while 20.39% of the learners had accessed both web-based and computer based formats. On the other hand, only 26.70% of the learners had accessed web-based content. Figure 4.5 shows a summary of learners Biology digital content access formats.

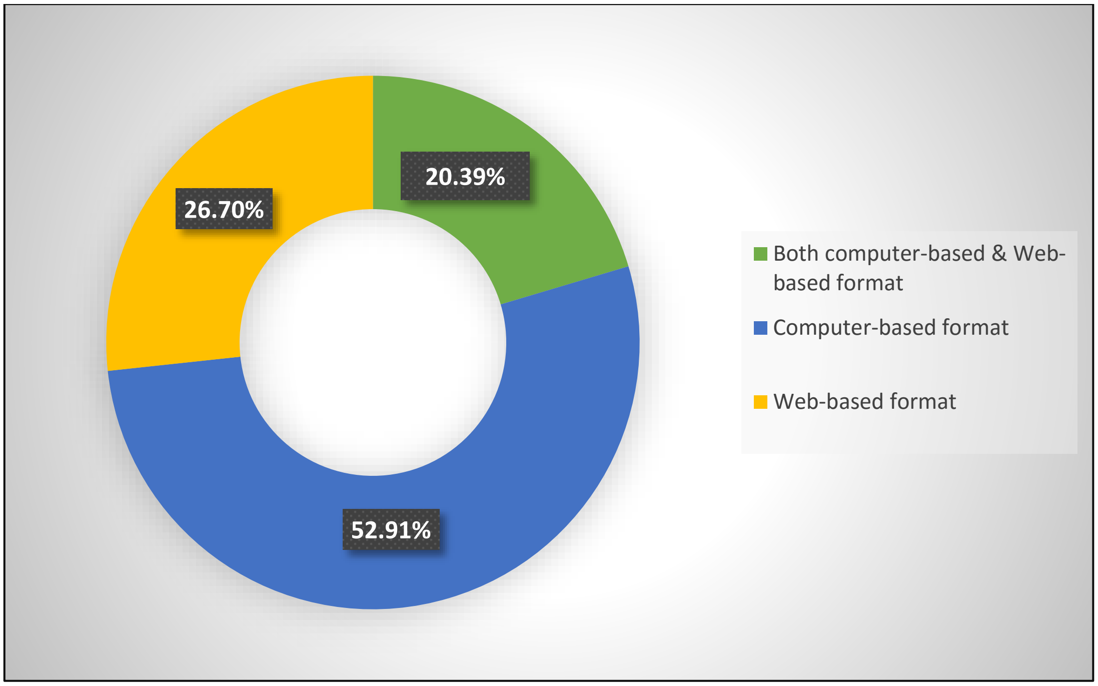

Figure 4.5: Learners' digital content access formats

From figures 4.4 and 4.5, it can be observed that more teachers and learners had accessed digital content in computer-based format as compared to the one in web-based format. One reason for the high number of teachers and learners having accessed computer-based content as compared to web-based content may be because the content provided by the ministry of education to ESP-ICT schools was computer-based packaged in DVDs. This may partially explain the low level of access and utilisation of digital in the instructional process.

Another reason could be the way digital content developers' package and disseminate their content. An assessment of the modes of packaging and dissemination by approved digital content developers revealed that 50% packaged and disseminated their Biology digital content in an offline mode only. This content is disseminated in computer-based formats such as CDs and DVDs. The other 50% indicated they had begun packaging and disseminating digital content in online formats but initially, they had their digital content in computer-based format only. Provision of most of the digital content in only one access format may have made it difficult for some teachers and learners to access and utilize Biology digital content. This is because the type of the format in which digital content is provided determines how such content can be accessed. Computer-based digital content for example can only be accessed from the device where it is located. This implies that you have to contact such a device to access the digital content. This is in contrast to web-based content which can be accessed online without necessarily contacting the device where the content is located.

4.3.4 Preferred digital content access formats

On the preferred formats of digital content access, more teachers (40%) favoured web-based content as compared to computer-based (23.3%). A considerable number of teachers (36.7%) preferred to access digital content both online and offline. Table 4.3 gives a summary of the teachers' preference in terms of digital content access formats.

Table 4.3: Teachers preferred digital content access formats

Content formats (n=30)	Percentage
Web-based format	40.0
Computer-based format	23.3
Both web-based and computer based formats	36.7
Total	100%

Majority of learners (70%) preferred the web-based formats while 23.3% were comfortable with computer based formats. Only 6.7% of the learners favoured a combination web-based and computer digital content format. Figure 4.6 gives a summary of the learners' preference in terms of content access formats.

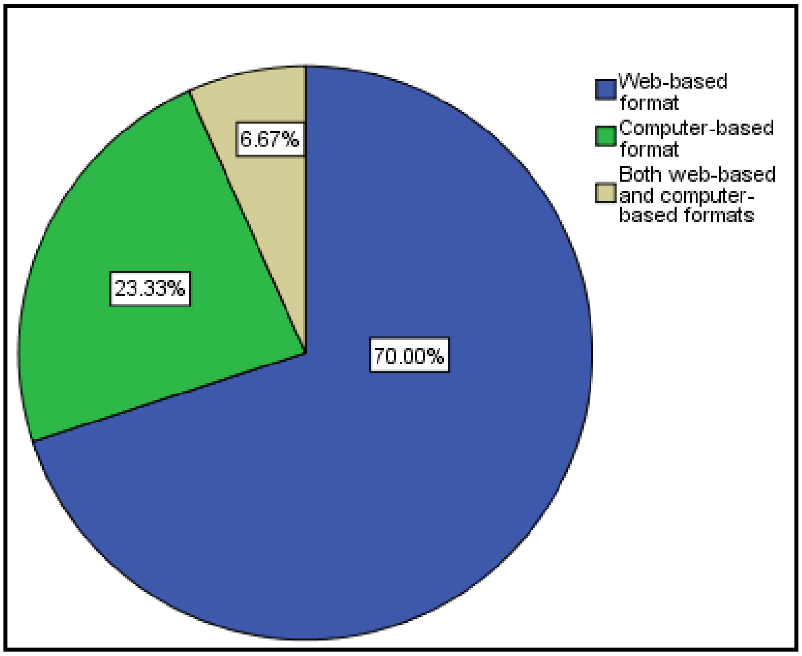

Figure 4.6: Learners preferred digital content access formats

Majority of the teachers and learners preferred online access of digital content as opposed to the offline format. This was due to the simple reason online digital content is easy to access anywhere, anytime as long as you have internet connectivity. This would eliminate the long procedures set by the school administrators in order to access digital content for instruction. 36.7% of teachers and 6.7% of learners preferred content disseminated in both online and offline modes. This would probably make it even easier to access digital content for instruction. This is because online digital content would be accessed from any place, anytime if internet is available and the offline versions would be utilised when and where internet is not available. Packaging and disseminating digital content in both web-based and computer-based formats would perhaps improve the level of access and utilisation of digital content in the Biology instructional process.

4.3.5 Devices used for access and storage of the content

Devices used for access and storage of digital content may also determine the level of content utilisation and consequently its influence in the instructional process. If content is stored and accessed using bulky devices such as local hard disks of desktop computers, then the level of utilisation might be low since they are not portable. Subsequently, these devices are not readily accessible for use whenever they are required limiting accessibility of the content. Conversely, if content is packaged and stored in smaller portable devices like memory cards and accessed using hand held portable devices such as tablets and other mobile devices, then it would be easier to carry and use the content from many different places.

Teachers were asked to indicate the kind of devices they used to access Biology digital content. A sizable percentage (30.7%) of teachers indicated that they accessed digital content through both computers and mobile devices whereas 24.1% used computers only. A relatively small percentage (20.2%) indicated that they accessed Biology digital content via computers, mobile devices and television sets while 25% of them used a combination of computers and televisions to access the content. On the other hand, a substantial percentage of the learners (37.0%) used computers and mobile devices while only a small percentage (13.3%) accessed the content through a combination of computers, television and mobile devices. A further 31.1% of learners used a combination of computers and television sets while only 18.6 of the learners accessed the Biology digital content merely via computers. It can therefore be observed that the highest percentage of teachers and learners accessed the Biology digital content through a combination of computers and mobile devices. Figure 4.7 gives a summary of the devices used by learners to access Biology digital content.

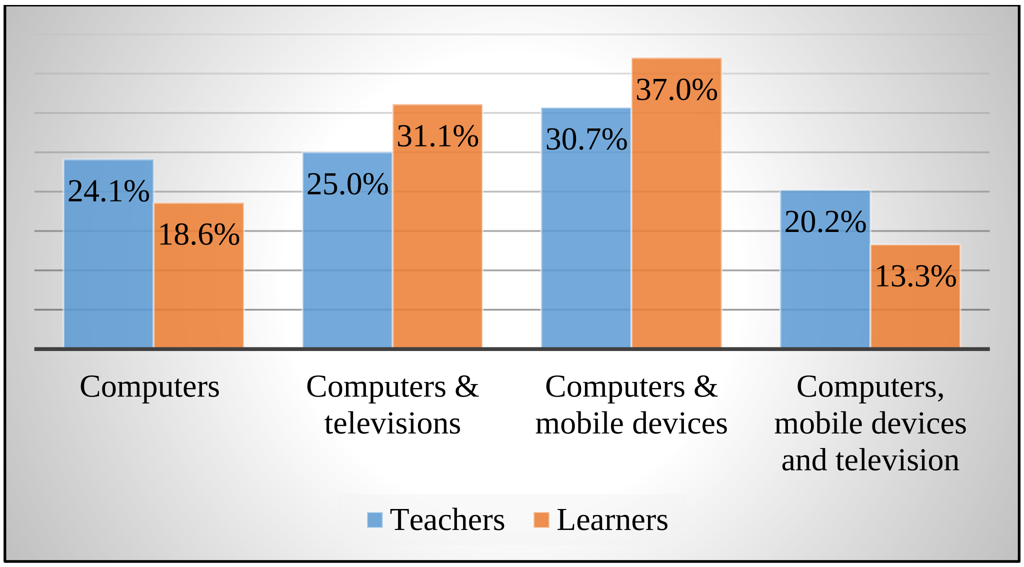

Figure 4.7: ICT devices used by teachers and learners to access digital content

On the content storage devices, DVDs were the most popular among both the teachers and learners with 23.6% and 24.1% respectively using them for curriculum digital content storage. This could be due to the fact that the content provided to these schools by the Ministry of Education was packaged in DVDs. A good number of teachers and learners also used memory cards for storage of digital content. This is associated with the high number of teachers' and learners' utilizing mobile devices and tablets to access the content. The ICT storage devices and space used by both the teachers and the learners is summarised on table 4.4.

Table 4.4: ICT storage devices and space

ICT storage device or space	Use by teachers (%) (n=24)	Use by learners (%) (n=150)
External hard disks	8.9	9.1
Local hard disks	14.4	14.9
DVDs	23.6	24.1
CDs	12.6	12.6
Flash disks	16.3	15.7
Memory cards	20.1	21.0
Cyber space/Cloud	4.1	2.6

Generally, all the teachers and learners who utilised Biology digital content indicated that they used computers whether solitary or in combination with other devices to access Biology digital content. Computers are less portable as compared to mobile devices such as tablets. In most schools, computers are kept and locked in ICT integration rooms or computer laboratories. This makes them inaccessible by teachers and learners when and where they need them. Accordingly, this limits the accessibility and utilisation of digital content in the instructional process.

On the content storage, a sizeable number of teachers and learners indicated that the content they utilised was stored in DVDs, local hard disks of the computers, external hard disks and CDs. These devices are less portable as compared to flash disks and memory cards. It could help therefore if computer-based content was packaged and disseminated in these more portable devices to increase the rate of access and utilisation of digital content in the instructional process.

Even more disturbing is the fact that only 4.1% of teachers and 2.6% of the learners indicated that they utilised digital content stored in the cloud. The current trend is to access and save documents in the cloud. Examples of cloud service or online storage include Google drive, Drop box, One drive and iCloud. Cloud would be the most ideal storage space for digital content since it is possible to access it anywhere and anytime you need it as long as you have internet connectivity.

Digital content developers need to consider and embrace cloud storage to improve access and utilisation by teachers and learners. Content stored in the cloud is easily accessible using basic mobile devices such as tablets. Considering the high penetration of mobile devices, then majority of the teachers and learners would be able to access and utilize digital content without necessarily going to the computer laboratories and ICT integration centres.

4.4 Influence of curriculum digital content utilisation on the Biology instructional process

Based on the data collected, analysed and discussed in objective one, it is evident that the study schools had access to Biology digital content that teachers and learners utilised to some extent. This study therefore sought to find out if utilisation of the Biology digital content available in the study schools had any influence on the instructional process. To do this, three factors in the Biology instructional process were considered including syllabus coverage, learners' assessment mode and the achievement. Three instruments were used to obtain this data. These instruments include Biology teachers' questionnaire, learners focus group discussion guide and documents analysis sheet.

4.4.1 Influence of the Utilisation of Biology digital content on syllabus coverage

Coverage of the syllabus is one of the factors that needs to be considered in any instructional process. Various studies have shown that there is a relationship between syllabus coverage and the performance of learners in examinations. Amadalo et al. (2012) indicated that a positive relationship exists between syllabus coverage and performance of learners at national examinations. Nakhanu (2012) concluded that syllabus coverage has a significant effect on student performance at KCSE level. KNEC (2011) argued that teachers should cover the syllabus adequately to enable learners perform better in examinations. Nearly all the teachers (91.3%) who filled the questionnaire indicated that learners performed better when they cover the syllabus before taking examinations. This study therefore sought to find out whether use of curriculum digital content had any influence on the coverage of Biology syllabus.

Teachers were asked whether utilisation of curriculum digital content had any influence on the coverage of the Biology syllabus. More than half of the teachers (63.4%) indicated that use of digital content in Biology could improve the pace of syllabus coverage. They argued that Biology digital content enhances understanding of difficult concepts and therefore it makes it possible to cover more content in a given period of time. Nonetheless, 36.6% of the teachers said that utilisation of digital content in the instructional process did not affect coverage of the Biology syllabus. These are likely to be some of the teachers who never utilised Biology digital content in the instructional process.

When the same question was posed to learners during their guided group discussions, half of the learners argued that use of Biology digital content can improve syllabus coverage. A student from Kangemi high school disclosed that:

> I enjoy and understand Biology better whenever our Biology teacher use videos and animations to teach us. I understood competition and predation in Ecology easily when we viewed the video clips in class. Cell division and the process of fertilization in plants and animals was also easy and interesting when I saw the videos and animations during our Biology lesson.
> (*Form Three Biology student from Kangemi High School, Nairobi*)

The learners thus argued that they learn and understand Biology concepts faster when taught using digital content with appropriate multimedia elements. This is most likely because multimedia elements make it easy for them to visualise abstract concepts.

To ascertain these arguments, this study sought to find out whether there was any difference in syllabus coverage between the groups that often-utilised Biology digital content and the ones that did not or rarely utilise the content. The group that frequently utilised Biology digital content in the instructional process was labelled A, while the one that did not or rarely utilise the content was labelled B. Records of work provided by the Biology teachers and learners notes were analysed to ascertain the number of Biology topics covered by each group at the end of second term in Form Three. Learners’ notes were used as a means to verify that; what teachers had indicated in their records of work was the actual status in syllabus coverage in their classes.

These data were recorded in the documents analysis sheet and used to compute the mean, standard deviation and the standard error mean for the two groups based on the number of Biology syllabus topics covered within the target period. Table 4.5 summarises the results obtained.

Table 4.5: Mean, standard deviation and standard error mean for Biology syllabus topics covered

Data source	Group	Mean	Std deviation	Std error mean
Records of work	Group A	4.1275	0.86512	0.12114
	Group B	4.0769	0.80735	0.12928
Learners notes	Group A	4.1222	0.71633	0.10678
	Group B	4.0667	0.83666	0.12472

The means of the syllabus coverage for the two groups were then compared using a two sample Student's t-test at 0.05 level of significance. Equal variances were assumed since the p-values for F-tests (0.830 and 0.573) were greater than 0.05. The results are summarised on table 4.6.

Table 4.6: Comparison of Biology syllabus coverage between Group A and B

Data source	t-value	p-value	Mean difference	Confidence interval (95%)	
Records of work	0.283	0.778	0.05053	-0.30485	0.40590
Learners notes	0.338	0.736	0.5556	-0.27074	0.38185

From the results, it can be observed that the p-values (0.778 and 0.736) for the t-test are greater than α value of 0.05. This suggests that there was no statistically significant difference between the two means at 0.05 confidence level. Thus, it can be concluded that there was no significant difference in syllabus coverage between the group that frequently utilised digital content to study Biology (Group A) and the one that rarely or did not utilise the content (Group B). This implies that utilisation of digital content in the instructional process has no influence on Biology syllabus coverage.

However, majority of the teachers and learners had indicated that use of digital content may enable them cover the Biology syllabus faster. The difference between their view as the actual users of the digital content and the statistical findings could have resulted from the following factors which have been discussed in various sections of this study.

- It was observed most of the content available in schools was revision and general reference content. This kind of digital content is not preferred for classroom lesson delivery. This is because while general reference material does cover the whole syllabus, revision materials tend to be shallow and more focused on revision areas. This implies that the digital content available was likely to have been mostly used for revision purposes other actual lesson content delivery which results in syllabus coverage.
- Majority of the teachers also indicated that they utilised Biology digital content for revision. This means that although a considerable number of teachers utilised Biology digital content in the instructional process, it was not used for the purpose of syllabus coverage. It was being utilised to enhance learners understanding of various concepts after lesson delivery.

- Another reason could have been the issues with the content interface especially the navigational tools as indicated in section 4.6. The navigation buttons were not standardised across different types of Biology digital content. This means that even teachers who utilised the content during lesson delivery are likely to have spent a substantial time teaching learners how to navigate through the content. In addition, most of the content analysed lacked secondary navigational or support tools such as search, help and glossary. This denied the learners and users an opportunity to easily search the content they wanted to cover. Moreover, they could not easily get help when stuck or even get the meaning of technical terms without much struggle. The time lost in the navigation process diluted the gains achieved in terms of learners understanding the concepts faster. Those using Biology digital content in the instructional process were thus unable to cover more content in a given period of time as compared to their counterparts who never utilised the content.

This may have resulted to lack of a significant statistical difference in terms of syllabus coverage between the two groups despite learners and teachers' opinion that use of digital content may enhance their syllabus coverage.

The finding of this study that use of digital or multimedia content is in consistent with various studies and observations made by other scholars. Najjar (1996) observed that multimedia content does not always improve the pace of learning a material as compared to mono-media or traditional instruction techniques. There are specific circumstances in which multimedia content may help learners to learn faster. These include when the media promote dual coding of information, when the media support one another and when the media are presented to learners with low prior knowledge on the area being learned. Analysis of the multimedia elements and content layout as outlined in section 5 and 6 of this dissertation revealed some issues on how the elements are combined. They appeared not support each other and in most cases multimedia elements were presented independently. Multimedia elements that do not support each other are unlikely to improve the pace of learning a certain material (Najjar, 1996).

However, some scholars have also indicated that use of multimedia or digital content enables learners to study a material faster. Fletcher (1990) examined 75 learning studies and found that participants learned the material faster and had better attitudes toward learning the material when it had interactive elements. Learners enjoy multimedia, prefer learning materials with multimedia, and trust that multimedia materials help them learn faster (Sewell & Moore, 1980; Bosco, 1986; Fletcher, 1989, 1990). Kulik, Bangert, and Williams (1983), observed that learning a certain material took less time when multimedia instruction was used as compared to tradition lecture technique. Kulik, Kulik, and Schwalb (1986) identified 13 studies in which learners using multimedia content learned in seventy-one percent less time than learners in traditional classroom instruction. In a research that involved eight studies, Kulik, Kulik, and Cohen (1980) found that multimedia instruction took about 2.25 hours while traditional classroom instruction took about 3.5 hours to cover the same material.

Studies on the influence of syllabus coverage or pace of learning a material due to utilisation of multimedia or digital content have therefore yielded different results. Researchers and scholars have made different conclusions. Results obtained in this study supports the idea that utilisation of digital or multimedia content does not improve syllabus coverage. The study has however given various reasons for such results which includes lack of course digital content in the study schools and issues with the user interface such non-standardised primary navigation and lack secondary navigation tools. Poor digital content layout where multimedia elements does not support each other was also considered as one of the reasons. Digital content developers need to come up with sufficient course digital content just like there are text books. Biology digital content navigational and support tools also need to be improved and standardised.

4.4.2 Influence of the utilisation of Biology digital content on learners' assessment

Assessment is one of the most important elements of any curriculum. According to Brown and Knight (1994), Assessment is at the heart of the student experience. Ramsden (1992) argued that assessment always defines the actual curriculum from learners' point of view. He continues to argue that assessment defines what students regard as important and how they spend their time. In education, the term assessment refers to the wide variety of methods that educators use to evaluate, measure, and document the academic readiness, learning progress, and skill acquisition of students from preschool through college and adulthood (Hidden curriculum, 2014).

This study therefore sought to investigate whether use of digital content influenced assessment of learners in Biology. Teachers were asked to indicate whether use of digital content had any influence on the learners' assessment. A significant number of teachers (56.7%) indicated that learners' assessment was affected by utilisation of digital content. A list of Likert items was then used to get teachers view on various factors related to learners' assessment. These factors included frequency of assessment, variety of test items, feedback duration, adequacy of assessment and interactivity of assessment methods. The six factors were rated using a five-level rating scale. These levels included 1-strongly agree, 2-agree, 3-not sure, 4-disagree and 5-strongly disagree (Appendix I). This data was then analysed in percentages to get the highest and lowest ratings.

Most teachers (57.7%) were of the opinion that the frequency of learners' assessment had improved as a result of Biology digital content utilisation in the instructional process. They explained that since digital content had ready assessment items, it was very easy to administer assessment questions after covering a few Biology concepts. Marking these test items was much easier since the systems had inbuilt feedback mechanism. On the variety of items used for assessment of learners, majority of teachers (60.3%) agreed that digital content provided more varieties of assessment items in Biology. They observed that the content test items like *drug and drop, word puzzles, click on the answer, jumbled words, jumbled letters, cross words and hot spots* are not found in the ordinary assessment methods they use without digital content. Nearly three quarters of the teachers (70.1%) also pointed out that learners could receive immediate feedback when they take the assessment provided in the digital content.

On the adequacy of assessment, most teachers (85.1%) were of the view that digital content did not provide adequate assessment to learners. They argued that the assessment items provided in the digital content that was available to them were not enough for the learners. As per the interactivity of the assessment, a considerable number of teachers (69%) agreed that digital content made Biology assessment more interactive and interesting to learners. The opinion of teachers on the effect of Biology digital content on learners' assessment is summarised on table 4.7.

Table 4.7: Teachers opinion on learners' assessment

	Assessment factors (n=30)	SA	A	NS	D	SD
1	Learners assessment is more frequent with Biology digital content	37.3	20.4	21.1	12.3	9.9
2	Learners can be assessed using a variety of test items	41.1	19.2	18.6	19.9	1.2
3	Learners are given feedback immediately	35.4	34.7	2.1	17.2	10.6
4	Assessment of learners is adequate	12.1	11.6	3.3	38.7	46.4
5	Assessment methods are more interactive	43.4	25.6	7.8	18.6	4.9

A list of Likert items was also used to explore the learners' opinion on how utilisation of Biology digital content affected their assessment. Learners were given five items related to digital content and assessment and were asked to rate them during their guided group discussion sessions. An overwhelming majority of learners (97.4%) indicated that digital content made it possible for them to assess themselves during their personal study timings. All the learners agreed that digital content provided them with immediate feedback after an assessment test while most of the learners (84.3%) also indicated assessment through digital content was more interesting than assessment through the ordinary methods used by teachers. In addition, majority of the learners (89%) indicated that they were in control of their own assessment when using digital content to study Biology. However, 70% of the learners felt that Biology digital content did not provide adequate assessment items for them. Table 4.8 summarises the opinion of learners on digital content and assessment.

Table 4.8: Learners opinion on digital content and assessment

	Assessment factors (n=150)	SA	A	NS	D	SD
1	I am able to assess myself during my personal studies	87.1	10.3	1.1	1.5	0
2	I receive immediate feedback after assessment	91.3	8.7	0	0	0
3	The assessment provided in the digital content is interesting	45.2	39.1	2.1	11.0	2.6
4	Enough assessment items are provided	11.2	12.1	6.7	30.6	39.4
5	I am able to control my own assessment	43.4	45.6	7.1	3.9	0

From these results, it can be observed that both teachers and learners indicated that most assessment factors improved with the use of digital content apart from the adequacy of assessment. Black and William (1998) observed that improvement in classroom assessment will make a strong contribution to improvement in learning. Factors like frequency of assessment, variety of assessment items, interactivity of the assessment and duration of feedback are shown to have improved with the utilisation of the Biology digital content. Black and William (1998) outlined that studies show firm evidence that innovations designed to strengthen the frequent feedback that students receive about their learning yield substantial learning gains.

Both teachers and learners indicated that digital content provided immediate feedback to the learners. Crooks (1988) indicated that Feedback to learners should be given regularly and while still relevant. Keller (1983) pointed out that that providing immediate, positive, verbal praise and informative feedback in a context that does not control the consequences of the performance may improve intrinsic motivation of the learners. Proper use of Biology digital content could therefore improve learners' assessment and consequently improve their conceptualization and performance in the subject.

4.4.3 Influence of the utilisation of Biology digital content on learners' achievement

Achievement is a quantifiable behavior in a standardized series of assessment tests (Simpson and Weiner, 1989). Conferring to Bruce and Neville (1979), educational achievement is measured by achievement tests developed for school subjects. Normally, achievement in such tests is expressed in form of test scores. A test score is a summary of the evidence contained in examinees responses to the items of a test that are related to the subject being tested (Thissen and Wainer, 2001). Achievement is therefore very important in teaching and learning since they give information about learners' performance in a specific area or subject. This study therefore sought to find out whether utilisation of curriculum digital content for instruction had any influence on the learners' achievement in Biology.

During the study, teachers were asked whether utilisation of Biology digital content had any influence on the learners' achievement. Slightly more than half of the teachers (52.1%) indicated that learners who used digital content in Biology scored higher in the tests than their counterparts who do not utilize the content. They pointed out that Biology digital content enhance understanding of difficult concepts, promote content retention and stimulate learners' interest in the subject. However, 41.3% of the teachers argued that use of digital content had no influence on learners' scores in Biology while 6.6% were not sure. When the same question was posed to learners during guided group discussions, nearly three quarters of the learners (73.3%) said that use of Biology digital content could make them get better scores in Biology. They also pointed out that digital content was very interesting to them and made them understand some concepts better than when they use textbooks. Some of the learners (36.7%) nevertheless thought that use of Biology digital content would not have any influence on their achievement.

Teachers' progress records for the sampled learners in six end of term assessment tests were then examined and the scores recorded in the document analysis sheets. The learners scores were achievement was categorised into two based on the utilisation of Biology digital content. Group A consisted of scores of the learners who frequently utilised Biology digital content in their studies while group B consisted of the scores of the learners who rarely or never used Biology digital content in their studies. The means, standard deviation and standard error means for scores obtained from the teachers' progress records for both Group A and Group B were then computed. Table 4.9 gives a summary or the results obtained.

Table 4.9: Mean, standard deviation and standard error of the learners' achievement

Group	Number of learners (n)	Mean	Std deviation	Std error mean
Group A	150	6.40	0.98	0.19
Group B	150	5.79	1.12	0.21

A comparison of the means from the achievement between the learners who utilised Biology digital content frequently (Group A) and the ones who rarely or never utilize the content to learn Biology (Group B) was therefore done. This was achieved by comparing the means using a two sample Student's t-test at 0.05 level of significance. Equal variances were assumed since the p-value for F-test (0.63) was greater than 0.05. The results are summarised on table 4.10.

Table 4.10: Comparison of learners' achievement in Biology

Number of learners (n)	t-value	p-value	Confidence interval (95%)	
300	2.166	0.036	0.078	1.171

From the results, it can be observed that the p-value of 0.036 for the t-test is smaller than α value of 0.05. This suggests that there was a statistically significant difference between the two means at 0.05 confidence level. Thus, there is evidence to conclude that there is a difference between the achievement of the learners who utilised digital content frequently to study Biology (Group A) and the ones who rarely or never utilize the content (Group B). This implies that utilisation of digital content in the study of Biology has a positive influence on learners' achievement in Biology. These results are consistent with various studies that have been conducted by scholars in this area before. Sterling and Gray (1991) conducted a study on the influence of the computer stimulation programs on the students' tendencies and their response to the statistics course. After analyzing the study results, the study found out that there was a statistically significant difference in the cognitive achievement in favor of the experimental group.

Fraser and Walberg (1995) noted that the use of computers for instruction resulted in increased student interest, cooperation and achievement in science. Allen (1998) conducted a study to find out the efficiency of multimedia software in the academic achievement of a sample from Texas University in the microorganism curriculum, their knowledge retention, and their attitudes toward using multimedia computers in teaching the microorganism course. The study result revealed statistically significant difference, in the academic achievement, knowledge retention and attitude towards computer, in favor of the experimental group which studied using the multimedia method over the control group which studied using the traditional method. Salem (2000) dealt with the effect of using computer as an educational tool in teaching the curriculum of statistics on the development of statistical skills among the third-grade commercial secondary school students. The study results showed statistically significant difference in the average grades of the experimental and control groups in favor of the experimental group after teaching the program.

In a meta-analysis (Bosco, 1986; Fletcher,1990; Kulik, Kulik, & Schwalb 1986) examined various studies that compared learning content presented in some traditional instructional methods to learning the same content presented using multimedia instruction. The data was collected in Biology and chemistry among other disciplines. The control group usually learned the information via classroom lecture practical. The comparison group covered the content using interactive videodisc or some other kind of computer-based instruction. The researchers measured learning using achievement tests. The analyses found that learning was higher when the information was presented via computer-based multimedia instruction than traditional classroom teaching methodologies.

AbuYunis (2005) studied the effectiveness of multimedia software to teach Geometry in the second grade of preparatory schools. The results revealed a statistically significant difference in the average of academic achievement of the experimental and control groups in the test conducted after the experiment in favor of experimental group. Nasr (2005) carried out a research to study the Effectiveness of the use of multimedia computer material on teaching geometry to the third preparatory grade students on students' academic achievement and the development of innovative thinking. The study revealed that there was a statistically significant difference between the average grades of the experimental and control group at the level of academic achievement. Ayere, Odera and Agak (2010) reported that there was a significant difference in academic performance between NEPAD and non-NEPAD schools attributed to e-learning. Jesse, Twoli and Maundu (2014) noted that there was a statistically significant difference in performance between the group that utilised computer assisted instruction and the one that utilised convention instructional techniques in Biology, Chemistry and physics.

However, it can also be observed that the mean difference value of 0.61 between the two groups is relatively small since it is less than 1. This may suggest that there was a slight difference between learners achievement in the two groups despite one group frequently utilising digital content to study Biology. The small values of the mean difference between the group that utilised digital content frequently and the one telly or never utilize the content suggest that although utilisation of the digital content had an influence on the learners scores in Biology, it was limited. This could be attributed to the design faults of the Biology digital content as discussed in sections 4.5 and 4.6 of this dissertation. Some of these factors include use of inappropriate and low quality multimedia elements, wrong content layouts, non-standard navigational tools and limited or lack and support tools that limit learners' control of the digital content.

4.5 Nature and influence of curriculum digital content multimedia elements on the Biology Instructional process

Another specific objective of this study was to analyse the nature and influence of multimedia elements in the Biology digital content in secondary schools. Multimedia elements include text, illustrations, animation, pictures, video, and sound (Najjar, 1998). Multimedia elements are essential in curriculum digital content since they are used to pass information and make the content more interactive and engaging to learners. Zaitoun and Kamal (2002) observed that multimedia elements make the reading process a dynamic one instead of the written presentation of the texts printed in books. This section therefore sought to analyse the types of multimedia elements in the Biology digital content and how teachers and learners rated them. In addition, the quality of the multimedia elements and how they influenced Biology digital content utilisation and instruction were considered.

Data were collected using the digital content analysis sheet, questionnaire for Biology teachers and the learners' Focus Group Discussion Guide. The content analysis sheet was used to analyse the types of multimedia elements in the Biology digital content available in the study schools. The questionnaire for Biology teachers and learners' focus group discussion guide were used to obtain data on how teachers and learners rated the multimedia elements in terms of occurrence in the digital content. They were also used to gather data on the rating of multimedia elements by teachers and learners in terms of their interest. In addition, data on the quality of the multimedia elements used in the digital content were obtained using the teachers' questionnaire.

Information gathered through these instruments helped the study to determine the types and quality of the multimedia elements used in the Biology digital content. Further, the extent to which each component was used and the interest of teachers and learners in terms of multimedia elements were established. The information also helped the study to find out whether the elements in the Biology digital content matched the interest of the teachers and learners. This data was critical in determining the utilisation and the influence of curriculum digital content on the Biology instructional process.

4.5.1 Types of multimedia elements in the Biology digital content

There are different types of multimedia elements that can be used in curriculum digital content. Common features of digital content include multimedia elements such as images and graphics, video, virtual reality, animations, simulations, audio, music, interactive and gaming elements (e.Republic, 2011). Multimedia elements in the Form 3 Biology digital content in the study schools were analysed and recorded using a multimedia elements analysis sheet. It was observed that the content was composed of various types of multimedia elements. These include:

- text,
- sound (voiceover and sound effects),

- animations,
- illustrations,
- videos,
- photographs
- exercises, quizzes, and activities (games).

The elements were in different proportions depending on the developer and type of the digital content. Most of the digital content (67.3%) analysed had all the seven multimedia elements. However, text and sound seemed to dominate the greatest part of these contents. About 11.9% of the digital content was made up of text and illustrations while 11.6% of the content analysed comprised of video clips with voiceover and text. Its only 9.2% of the content analysed that was composed of animations and voiceover. The content also lacked proper combination of multimedia elements that would maximise the amount of information processed by the brain. In many instances, elements were independent from each other for example a voiceover would explain a concept then an animation or video clip is presented. This way, the working memory would process the visual and the audio information differently rather than processing them at a go if they were presented at the same time. According to Mayer and Sims (1994), words and pictures presented concurrently are more effective than when presented sequentially. Sweller (2005) also observed that using multiple channels can increase the amount of information that the brain can process. This means that when content is presented using both the visual and auditory channels, working memory can handle more information overall.

Although digital contents have different types of multimedia elements, the proportion and quality of these elements determine the effectiveness of the content in an instructional process. The type and proportion of multimedia elements in digital content are some of the aspects that determine how interesting the content can be to the user besides how well a concept is explained using the content. For example, some users are more interested on video clips while others prefer animations. Similarly, some concepts are better explained using video clips while others come out clearly when animations are used. Aloraini (2012) argued that video clips help to get information closer to reality. This makes concepts presented in video clips more real and therefore such information is easily retained in the brain for a longer time.

Concepts like predation and competition are better taught using video clips which can be well captured in national parks or game reserves and would appear close to reality than when presented in a classroom situation in traditional techniques like lecture. Other concepts like cell division and fertilization in the topic of reproduction in Form Three Biology would be better presented as animations to capture the details which would not be easily captured using a video camera. In addition, a visual like video clip accompanied by well harmonised narration enhances processing of the information by the working memory since both audio and visual channels are properly utilised through sight and hearing. Shank (2005) pointed out that one should use multimedia that effectively employs verbal and visual processing channels to help learners integrate content with prior knowledge. Najjar (1998), indicated that information that is processed through both verbal and pictorial channels appears to be learned better than information that is processed through just the verbal channel or just the pictorial channel.

According to Aloraini (2012), use of multimedia is one of the best educational techniques because it addresses more than one sense simultaneously, that is, the sense of sight and hearing. For example, during a focused group discussion with learners, a girl from Murang'a road secondary school noted the following:

> The content (Biology digital content) has assisted me to understand difficult concepts in Biology. Areas like double fertilization in plants, meiosis and mitosis are now very clear to me after viewing animations in the content.
> (*Biology student in Form Three- Murang'a road secondary school* - *Nairobi*)

This implies that the animations were interesting to the learner and at the same time brought out the concepts of double fertilization in plants, mitosis and meiosis clearly. Moreover, the animation may have been accompanied by a voiceover that maximised the processing of the information by the working memory. If a different multimedia element such photographs were used for the same concept, perhaps the learner would not have understood the concepts. According to Betrancourt (2005), animations appear to be the most effective when presenting concepts or information that student may have difficulty envisioning for they excite most senses. In this case, fertilization, meiosis and mitosis are easy for learners to visualise since these are internal processes where even practical experiments are not easily done.

A preferred digital content should have a variety of multimedia elements appropriately utilised to make it interesting and have a positive influence in the instructional process. The multimedia elements should be utilised in areas where they bring out the concepts most clearly. In Biology for example, most concepts in topics that involve the human body like Transport in animals, Gaseous exchange and Reproduction may have to be animated. On the other hand, concepts in topics that involve the external environment like ecology, growth and development and reception, response and irritability may be recorded in form of video clips. One multimedia component should not be over-utilised in digital content since doing so could make the content less interesting. The quality of multimedia elements used also determines the effectiveness of the content. Blurred video clips for example will make the content less interesting to users reducing the level of content utilisation and even the effectiveness of the content. The multimedia element used should try to engage both visual and auditory channels to enable the working memory to handle more information.

According to Sweller (2005), using multiple channels can increase the amount of information that the brain can process. For example, an animation used with a voiceover will ensure that some information is processed through the audio channel while the other information is processed through the visual channel.

4.5.2 Teachers' rating of multimedia elements in the Biology digital content

Teachers were asked to rate multimedia elements based on the extent to which they were used in the Biology digital content. The seven elements were rated using a four-point rating scale. The levels included 1- not common, 2- fairly common, 3- common and 4- most common. Elements that made up less than twenty-five percent of the content were rated as not common while the ones that comprised at least twenty-five but less than fifty percent of the content were rated as fairly common. Those that made up about fifty percent were rated as common while the ones that composed seventy-five percent and above were rated as the most common. Majority of teachers (56.7%) rated text as the most common multimedia element in the Biology digital content. Slightly more than a half (53.3%) of the teachers also rated sound as the second most common. This implies that these two components were the most available multimedia elements in the Biology digital content. A considerable number of teachers (43.3%) rated videos as not common meaning it was the least seen element in the Biology digital content. Animations and games were also rated as not common by 30% of the teachers. Table 4.11 gives a summary of the Biology teachers rating of multimedia elements according to their availability in the Biology digital content.

Table 4.11: Teacher' rating of multimedia elements by availability in digital content

Multimedia elements		Percentage rating per scale (n=24)			
		Not common	Fairly common	Common	Most common
1	Text	3.3	10.0	30.0	56.7
2	Sound	6.7	6.7	33.3	53.3
3	Animations	30.0	36.7	23.3	10.0
4	Illustrations	6.7	20.0	26.7	46.7
5	Videos	43.3	33.3	13.3	26.7
6	Photographs	6.7	23.3	43.3	26.7
7	Games	30.0	36.7	33.3	0

Teachers were also asked to rate the multimedia elements based on how interesting the elements were to the content user. A four-point rating scale was used for this rating. The rating points included 1- not interesting, 2- fairly interesting, 3- interesting and 4- very interesting**.** The multimedia elements that teachers considered to be the least interesting were rated as not interesting (1) while the ones considered as most interesting were rated as very interesting (4). The elements considered to be a bit interesting were rated as fairly interesting (2) while the ones considered to be interesting to a satisfactory level were rated as interesting (3).

Majority of the teachers (70.0%) rated animations as the most interesting multimedia element in the Biology digital content. Games and videos were also highly rated in terms of interest with 63.4% and 56.7% rating respectively. Most teachers felt that text was not interesting at all with only 3.3% rating it as very interesting and a massive 63.3% rating it as not interesting. However, it was the most dominant element in the Biology digital content in schools. This may affect the level of utilisation of Biology digital content by teachers. It may also affect the efficacy and hence influence of the content on the instructional process. A summary of the teachers' ratings of the multimedia elements based on their interest is provided on table 4.12.

Table 4.12: Teachers' rating of multimedia components based on interest

Multimedia elements		Percentage rating per scale (n=24)			
		Not interesting	Fairly interesting	Interesting	Very interesting
1	Text	63.3	23.4	10.0	3.3
2	Sound	43.3	20.0	16.7	20.0
3	Animations	0	3.3	26.7	70.0
4	Illustrations	20.0	63.3	10.0	6.7
5	Videos	0	20.0	23.3	56.7
6	Photographs	26.7	53.3	16.7	3.3
7	Games	0	3.3	33.3	63.4

A comparison of multimedia elements rating by teachers in terms of availability in the digital and teachers interest was then done using the most common rating (mode). The results revealed that teachers were more interested on animations, videos and games in Biology digital content. All the three multimedia elements were rated as very interesting with a mode of 4. However, video was rated as not common with a mode of 1 while animations and games were rated as fairly common with a mode of 2 based on their availability in the Biology digital content. On the other hand, text and sound were rated as not interesting with a mode of 1. Nevertheless, these two elements were the most dominant in the Biology digital content in schools with a mode of 4. Figure 4.8 gives a summary of the comparison of multimedia elements rating by teachers.

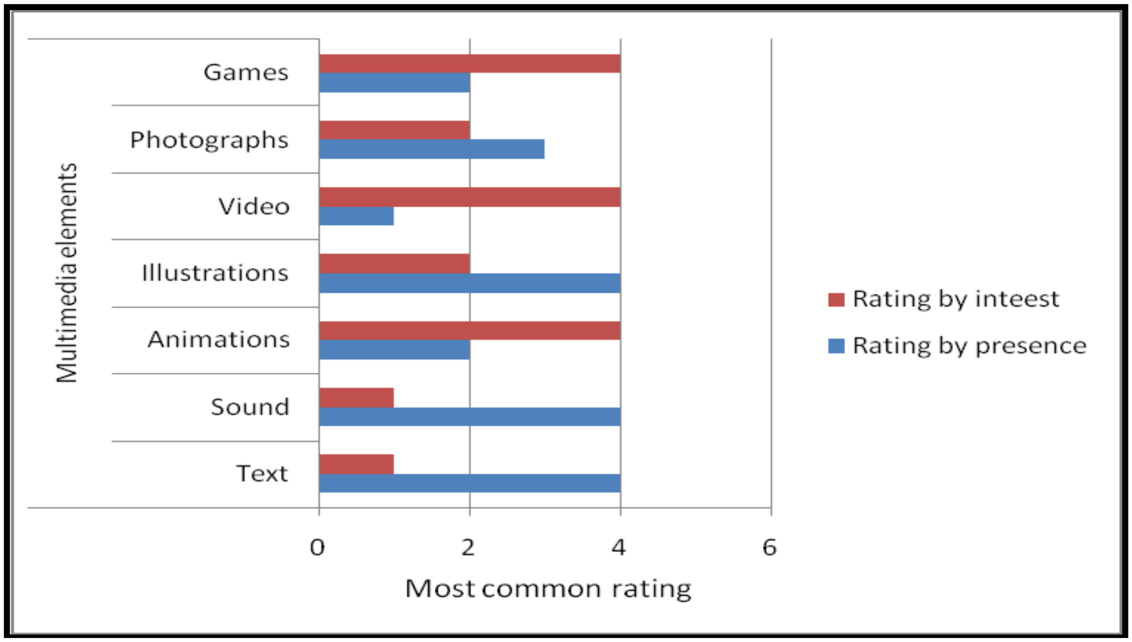

Figure 4.8: Comparison of multimedia rating by teachers

Although text and sound were the most common in the digital content as rated by teachers, they have a limitation in terms of learners' engagement. The two elements lack interactivities and thus limit learners' activity during content presentation. Consequently, the interest and attention of the learners are not captured. In most cases, animations and videos are interactive since they have the motion effect. Combined with sound and some text, they are able to bring out Biological concepts clearly as well as engaging both the audio and the visual channels of the learner. According to Marilyn, Ruth and Sarah (2010), participative engagement of learners creates an enjoyable environment, which provides the catalyst for active learning and conceptualization in science. Games which include quizzes, exercises and activities involve the learners directly making them practice what they have learnt with immediate feedback being provided. This is not only interesting to learners but also captures their attention and motivates them. According to Reeves (1998), Multimedia content can stimulate more than one sense at a time, and in doing so, may be more attention-getting and attention-holding.

If less interesting components are dominantly used in the digital content, such content is less attractive to the learners. Consequently, the level of utilisation of the digital content in the instructional process decreases since it is not interesting to the users. As a result, benefits that come with the utilisation of digital content such as better understanding of Biological concepts which may translate to enhanced achievement by learners are not realised. It would hence be important for content developers to consider incorporating more multimedia elements that are interesting such as games, videos and animations, while reducing the ones that are less interesting such as text and sound in the Biology digital content. This would in turn make the content more interesting to teachers. Subsequently, teachers would utilise the content more in the Biology instructional process leading a positive influence.

One way of doing this would be improving the process of digital content development. Doing proper analysis of the teachers and learners needs before development commences would be very useful. This would reveal the interests of the teachers early enough so that developers can ensure that they are catered for during development. Involving the right professionals during the development process is also critical. Experienced teachers for example would present the needs and interests of the learners during the development process.

4.5.3 Learners rating of multimedia elements in the Biology digital content

Learners also rated the seven multimedia elements based on the extent in which they were used in the Biology digital content and how interesting the elements were to them. They also used a four-level rating scale similar to the one used by the teachers. During their guided group discussions, text was rated as the most common (60.0%) multimedia element in the Biology digital content being utilised in schools followed by sound (50.0%). Videos and games were rated as the least common elements in the Biology digital content with 50% of the learners rating videos as not common. Games were rated as not common by 36.7% of the learners. Table 4.13 summarises the rating of multimedia elements by learners based on the extent to which they are used in the Biology digital content.

Table 4.13: Learners' rating of multimedia elements based on availability in the digital content

Multimedia elements		Percentage rating per scale (n=150)			
		Not common	Fairly common	Common	Most common
1	Text	6.7	10.0	23.3	60.0
2	Sound	13.3	16.7	20.0	50.0
3	Animations	16.7	36.7	30.0	16.7
4	Illustrations	30.0	23.3	26.7	20.0
5	Videos	50.0	33.3	10.0	6.7
6	Photographs	3.3	23.3	50.0	23.3
7	Games	36.7	33.3	23.3	6.7

Based on how interesting multimedia elements were to learners, videos and games were rated as the most interesting (60%) multimedia elements in the Biology digital content followed by animations at 56.7% rating. Text was rated as the least interesting multimedia element in the content with 50% of the learners rating it as not interesting. A summary of the learners' ratings of the multimedia elements in the Biology digital content based on the learners' interest is given on table 4.14.

Table 4.14: Learners rating of multimedia elements based on interest

Multimedia elements		Percentage rating per scale (n=150)			
		Not interesting	Fairly interesting	Interesting	Very interesting
1	Text	50.0	23.3	16.7	10.0
2	Sound	43.3	20.0	26.7	10.0
3	Animations	0	13.3	30.0	56.7
4	Illustrations	19.8	36.9	28.6	14.7
5	Videos	0	6.7	33.3	60.0
6	Photographs	13.3	40.0	36.7	10.0
7	Games	0	6.7	33.3	60.0

A comparison of multimedia elements rating by learners based on their availability in the digital content and how interesting they were to learners was also done. The mode which represented the most common rating by the learners was used for the purpose of comparison. The results revealed that learners were more interested on videos, animations and games when using Biology digital content than text and sound. All the three multimedia elements were rated as very interesting with a mode of 4. However, video and games were rated as not common with a mode of 1 while animations were rated as fairly common in the Biology digital content with a mode of 2. According to SEG (2008), animations can help the learner visualise a process or another dynamic phenomenon that cannot be envisioned easily. Mayer (2005) also observed that narration and video is much more effective than narration and text. Text and sound were rated as not interesting by learners with a mode of 1. Nonetheless, these two elements were the most commonly used in the Biology digital content in schools with a mode of 4. Figure 4.9 summarises the comparison of multimedia elements rating by learners.

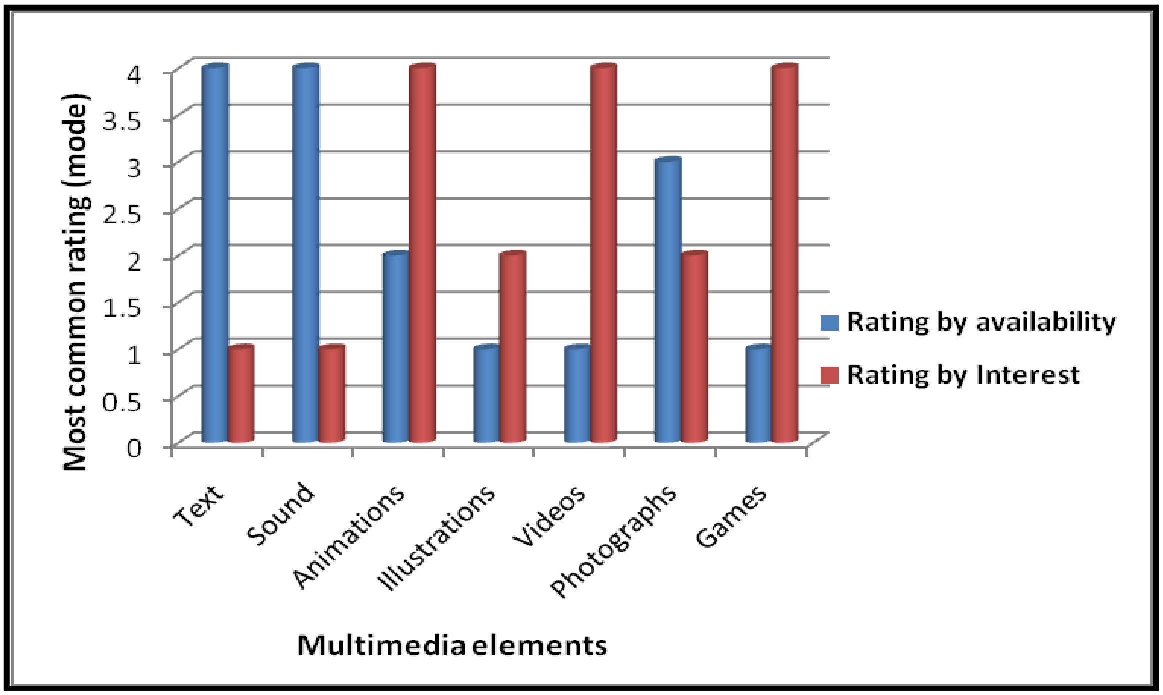

Figure 4.9: Comparison of multimedia by learner rating

Digital content that is dominated by less interesting multimedia elements is not attractive to the learners and does not arouse their interest and attention during utilisation. As a result, the level of utilisation of the digital content by learners was low.

Benefits that come with the use of digital content such as better understanding of Biological concepts which may translate to enhanced achievement by learners are not realised. According to Jesse et al. (2014), interest of learners plays an important role in the instructional process. It triggers learners' engagement therefore creating an enhanced environment for teachers to positively exploit. This then leads to improved performance. It is therefore critical for content developers and designers to increase the number of elements that are more interesting to the learners while reducing the ones that are less interesting in the Biology digital content. This would in turn make the content more interesting to learners increasing their utilisation levels. Consequently, the full influences of the utilisation of digital content in the Biology instructional process would be realised.

Proper assessment and analysis of the learners needs before development of the digital content could help improve it in terms of multimedia elements. This would expose the interests of the learners before the real content development starts thus guiding the developers on the inclusion of the elements in the content. The right professionals or specialists also need to be involved in the content development process. Experienced teachers for example would present the needs and interests of the learners during the development process while multimedia designers would develop the required multimedia components.

4.5.4 Quality of multimedia elements in Biology digital content

Apart from the type of multimedia elements, the quality of multimedia components available in a digital content is very important and may determine its effectiveness in the instructional process. Shank (2005), argued that that well-designed multimedia elements can enhance motivation, learning, and transfer among learners. Teachers were asked to rate multimedia elements based on their quality as they appeared in the Biology digital content. Various features of the content were considered to determine the quality of the multimedia components. These included clarity of the elements, relevance to the topical areas, sound audibility and harmonization of elements. The six multimedia elements that include photographs, sound, text, video, illustrations and animations were rated using a five-level rating scale (Appendix I). These levels included 1-strongly agree, 2-agree, 3-not sure, 4-disagree and 5-strongly disagree. This data was then analysed in percentages to get the highest and lowest ratings and then the modes to get the most common ratings.

For the photographs used in the content, majority of the respondents (81.8%) felt that they were clear, that is, images were sharp, in correct proportions, right coloured and well labelled and captioned. All the respondents agreed that the photographs in the content were relevant to the topical areas. This may suggest that there was a high level of involvement of the specialists or professionals like teachers, instructional designers and multimedia designers during the development of the content. This ensured that the photographs were relevant to syllabus content and of high quality. Only 18.2 % of the teachers indicated that photographs were not clear. Among the areas that the teachers felt needed improvement was captioning, labelling and colouring of the photographs.

Sound was rated as clear by 68.1% of the respondents while 27.4% thought that the sound was not clear. All the sampled teachers agreed that sound in the content was audible and relevant to the topical areas. However, some argued that the pace was fast for the learners while in some instances there was background interference. Some also observed that sound was not well harmonised with the text and other multimedia elements in some instances. The pace could have been fast in some cases because some digital content available in schools was not locally developed but customised from other countries like India. This means that the voiceovers were not recorded by local sound artists and therefore learners who are used to local voiceovers may have difficulties. Background interference may have resulted from lack of proper sound recording facilities like studios or improper editing skills. Harmonisation of the sound with text and other multimedia elements could be addressed by having the right professional, basically instructional and multimedia designers working in harmony.

The bulk of the teachers (68.2%) indicated that videos clips in Biology digital content were clear. The common areas of concurrence included the pace of the video clips and the logical flow of the images. Nevertheless, 31.8% of the teachers said that the videos were not clear. They were concerned with the sharpness of the video images where they felt that some of them or some parts were blurred. On the harmonization of video with sound and text, 54.6% agreed that there was harmony while 36.4% disagreed. Almost all the respondents (90.9%) indicated that the video clips in the content were relevant to the topical areas. Blurred images could have been caused by use of low definition equipment of shooting videos or poor video shooting or/and editing skills. Lack of harmony between video images, voice and text may have resulted from poor editing skills. This could be solved by engaging qualified and experienced video technicians and using the right equipment such as high definition cameras for shooting the video clips.

Half of the respondents (50%) agreed that the illustrations in the digital content were clear while the other half disagreed. All of them generally agreed that the illustrations were in the correct colours and proportions. Some however felt that the illustrations were not properly labelled and /or captioned and the images used were not sharp. On the relevance to topical areas, 54.6% of the teachers indicated that all the illustrations were relevant while 40.9% disagreed. Proper labelling and captioning of the illustrations could be achieved by engaging qualified and experienced illustrators. To improve relevance, the illustrators should consult well with qualified experienced teachers, curriculum developers and content designers.

Most of the teachers in the study (86.3%) pointed out that animations in the content were clear. The 13.7% who disagreed had an issue with the sharpness of the images used in the animations. On harmonization with other elements, 58.9% were of the view that animations were well synchronized with text and sound while 36.4% thought they were not. On the relevance of animations to the topical areas, 58.9% of the teachers agreed they were relevant while 36.4% disagreed. Harmonization and relevance of animations could be addressed by involving qualified and experienced animators, content developers, curriculum developers and teachers and ensuring that they consult widely during the development process. A summary of the rating of the quality of multimedia elements in the Biology digital content is given on table 4.15.

Table 4.15: Rating of the quality of multimedia elements in the Biology digital content

	Feature of multimedia element (n=22)	Strongly agree	Agree	Not sure	Disagree
i	Clarity of photographs	22.7	59.1	0	18.2
ii	Relevance of photographs	45.5	54.5	0	0
iii	Clarity of sound	13.6	54.5	4.5	27.4
iv	Harmonization of sound and text	13.6	54.5	4.5	27.3
v	Clarity of the video clips	18.2	50.0	0	31.8
vi	Relevance of the video clips	54.5	36.4	0	9.1
vii	Harmonization of the video with sound and text	9.1	45.5	9.1	36.4
viii	Clarity of illustrations	9.1	40.9	0	50.0
ix	Relevance of the illustrations	9.1	45.5	4.5	40.9
x	Clarity of animations	22.7	63.6	0	13.6
xi	Harmonization of animations with sound and text	4.4	54.5	4.5	36.4
xii	Relevance of animations	9.1	54.5	0	36.4

Generally, most of the multimedia elements were rated to be of a considerable high quality based on clarity, relevance and harmonization with other elements. On the most common rating, all the elements had a mode of 2 apart from relevance of videos which had a mode of 1. Table 4.16 gives a summary of the most common (mode) rating of the multimedia elements by selected quality determination aspects.

Table 4.16: Most common rating of multimedia elements

Multimedia element	Rating on various quality determination aspects		
	Clarity	Relevance	Harmonization
Videos	2	1	2
Sound	2	2	2
Animations	2	2	2
Photographs	2	2	2
Illustrations	4	2	2

These results show that teachers commonly agreed that the multimedia elements in the Biology digital content were of good quality. However, it is worth noting that it is only in the relevance of the videos where the teachers strongly agreed that videos used in the content were relevant. There was a variation on the view of respondents on the quality of some features of the multimedia elements in the digital content as shown on table 4.9. The most notable one is the clarity of illustrations which has a mode of four meaning that most teachers strongly disagreed that illustrations in the Biology digital content were clear.

Digital content with low quality multimedia elements has little utilisation level as well since it does not interest and capture the attention of the target users. Its effectiveness in teaching and learning process is also likely to be low since it does not bring out concepts clearly. Consequently, the positive influence of such digital content in the instructional process may not be realised. It is therefore of great importance to ensure that the digital content being developed and disseminated for utilisation in schools is of high quality. The multimedia elements in such digital content should be clear, relevant and well harmonized to enhance its quality.

In addition to capturing the interest of the learner, the quality of the multimedia elements in the digital content may determine the amount of learning that takes place during the utilisation. Patti (2005) underscores that eeffective multimedia for learning requires carefully combining media in well-reasoned ways that take advantage of each medium's unique characteristics. An analysis of the multimedia elements revealed most of them were overloaded, that is, they contained the visuals, voiceover and text at the same time. According to Sweller (1999), this situation creates split attention effect because the learner's visual attention is split between viewing the visual and reading the text. In this case, the visual channel is overloaded with information since it has to process the information that is being viewed on the visual and the text being read at the same time. As a result, little learning may take place even with the use of the multimedia elements.

It is therefore important to review and consider improving the process of digital content development to ensure that appropriate content is developed. Appropriate digital content would be the one consisting of a variety of high quality multimedia components well organized to achieve the best influences when utilised in the instructional process. According to Patti (2005), designing a quality multimedia content for instruction requires a team effort since many different design skills are required. For example instructional design skills to establish the purpose of the instruction and select instructional approaches and multimedia elements, writing skills to write content and multimedia scripts, content development skills to structure the content so that it is easy to follow, graphic design skills to develop clear and attractive graphics, multimedia skills to work with instructional designers to create interactive elements, research skills to collect and analyze information on the user needs and feedback, and programming skills to work on navigation and access platforms. This implies that different types of profession will have to be engaged and work in harmony to produce high quality interactive multimedia content for learning. This way, appropriate digital content that would lead to positive influences on the instructional process would be developed. This study revealed that the multimedia elements in the Biology digital content were generally of good quality. However, some elements like the clarity of the illustrations used in the digital content were found to be of low quality. Such multimedia elements thus require revision to improve their quality accordingly enhancing the quality of the Biology digital content.

4.5.5 Multimedia elements and the utilisation of Biology digital content

During this study, both learners and teachers were asked whether multimedia elements would influence their utilisation of curriculum digital content. Majority of the teachers (93%) and learners (97%) indicated that the nature of multimedia elements would influence their utilisation of the curriculum digital content. Teachers were asked to indicate the reasons why they thought their utilisation would be affected while learners were probed to give their reasons during the guided discussions. They all gave closely related reasons which include the following:

- Content with varied and adequate multimedia elements is more interesting to them and therefore they are likely to use more frequently.
- Multimedia elements enhance understanding of difficult concepts and this motivates them to use the content.
- Multimedia elements improve content retention since it is possible to read, hear and see the visuals.

According to Alfar (2009), Multimedia elements help learners remember & transfer their knowledge. Multimedia elements therefore promote content retention and understanding during the instructional process.

The level of utilisation of digital content and its influence on the instructional process depends on the variety, adequacy and quality of multimedia elements used. Teachers and learners tend to be more interested on digital content that has varied and adequate multimedia elements of good quality. Nugent (1982) found that the highest levels of learning were achieved when content was presented to learners through a combination of text and pictures or audio and pictures as compared to similar content presented through text, sound or pictures alone.

Digital content that has a variety and adequate multimedia elements is more interactive than content with a few multimedia elements of the same type. Interactivity makes the learning process responsive and active, governing a learning of participation and doing, not passive watching or merely listening (Teoh and Neo, 2007). Interactive multimedia learning promotes interaction between the learner and the learning content and the content with the learner. Research suggests that when such learning interaction occurs, learner's attention and comprehension of the learned subject increases. Fletcher, 1990 observed that interactivity has a solid positive effect on learning. Stafford (1990) analysed ninety-six studies and determined that interactivity was associated with learners' achievement and knowledge retention. Similarly, analysis of seventy-five learning studies revealed that learners cover a material quicker and have better attitudes towards it when exposed to interactive instructional environment (Bosco, 1986; Fletcher, 1989).

This study found that the Biology digital content in schools had a variety of multimedia elements including text, sound, animations, illustrations, photographs, videos and games. A closer analysis of the content confirmed that some elements mostly text and sound, were more prominent in the Biology digital content than others. In contrast, an examination of the teachers and learners interest in terms of multimedia elements revealed that they were more interested in animations, video clips and games.

An evaluation of the quality of multimedia elements also exposed some issues especially in clarity and harmonization. Multimedia elements quality aspects such as relevance, clarity and harmonisation affect the utilisation and effectiveness of curriculum digital content in the instructional process. Aloraini (2012) pointed out that effective use of multimedia as a facilitating strategy helps in delivering the educational material to students easily and has a positive influence on cognitive achievement, academic achievement, comprehension and application. These content quality aspects are likely to have led to some teachers and learners not utilising the Biology digital content despite the fact that it was available in their schools. Biology digital content should therefore have a variety and adequate quality multimedia elements to ensure that it has a positive influence in the instructional process.

4.6 Formulation and influence of curriculum digital content user interfaces on Biology instructional process

Another factor that affects the utilisation and influence of Biology digital content on the instructional process is the user interface. One of the objectives of this study was therefore to examine the formulation, and influence of user interfaces in secondary school curriculum digital content on the Biology Instructional process. Multimedia content user interfaces combine different media such as text, graphics, sound, and video to present information (Najjar, 1998). This study considered various elements of the user interfaces of the Biology digital content in the study schools. Among the elements considered included the arrangement of the components that make up the digital content, that is, *content layout, navigational (primary navigation) and support (secondary navigation)* tools in the content. It also sought to find out from teachers and learners whether these factors influenced their utilisation of digital content. To obtain this data, Biology teacher questionnaire, learners' focus group discussion guide and the digital content analysis sheet were used.

4.6.1 Layout of the Biology digital content components

The way digital content is organised is very important and may determine its utilisation and even influence in the instructional process. Well organized content is much more easy to use, more interesting to the user and consequently have a greater influence in the instructional process. Patti (2005) noted that Multimedia elements add complexity both to the screen and to the tasks that users need to perform. This therefore calls for a well-organized content in terms of the multimedia elements and navigational tools. Several studies show that adding closely related, supportive illustrations to textual or auditory verbal information improves learning performance.

This study examined how different elements of the Biology digital content were organized. To obtain this data, the multimedia elements in the content were classified into three categories that included *Graphics* (animations, illustrations, video clips and photographs), *sound* (narration and sound effects) and *text*. The researcher viewed the different types of Biology digital contents available in the study schools and recorded the layouts on the content analysis sheet. From this analysis, it was observed that Biology digital content in schools was organized in five different layouts. These included Graphics-sound-text, graphics-text-sound, sound-text-graphics, text-sound-graphics and all integrated layout. Most of the content analysed (49.1%) had the text-sound-graphics arrangement while 19.7% had an integrated layout. It is only 7.1% of the content that had sound-graphics-text kind of arrangement. Figure 4.10 shows a summary of the Biology digital content layouts as observed during the analysis.

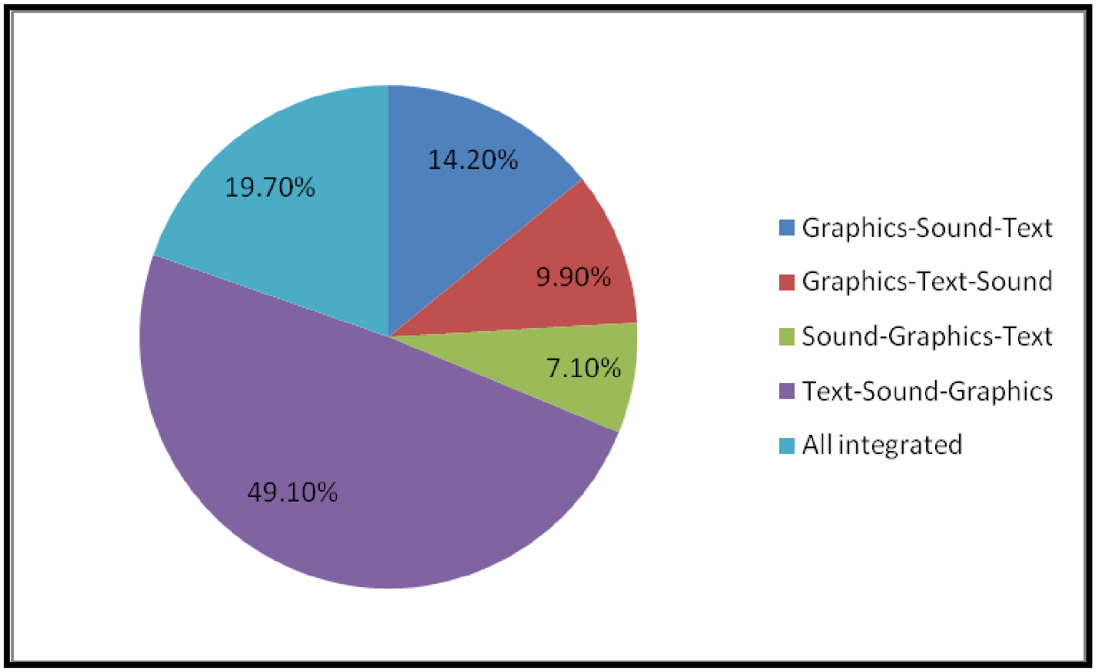

Figure 4.10: Content layout from data obtained using analysis sheet

On the Biology teachers' questionnaire, teachers were also asked to indicate the type of layout in the curriculum digital content they had accessed. Nearly half of the teachers (46.1%) were of the view that the content they had accessed was arranged as Text-Sound-Graphics while only 7.7% had accessed content with Sound-Graphics-Text kind of layout. A small number of teachers (22.2%) indicated that they had accessed Biology digital with an all integrated layout. Figure 4.11 summarises the layout of the content as indicated by teachers.

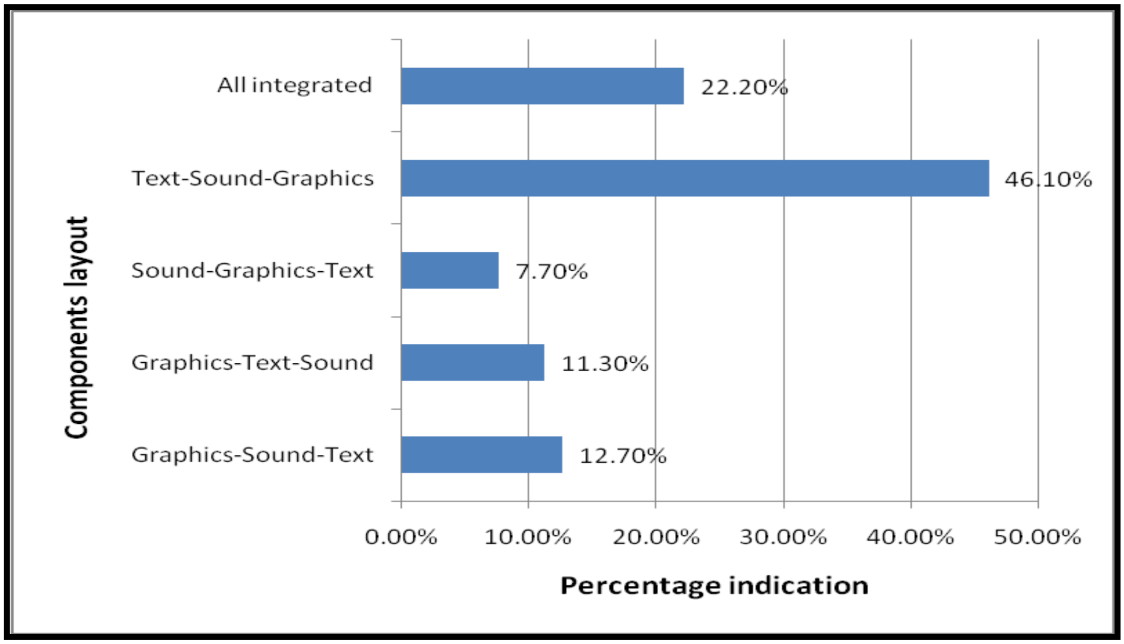

Figure 4.11: Content layout as indicated by teachers

Learners were also probed for their view during the guided group discussions. Nearly half of them (48.9%) indicated that Biology digital content they had accessed had a Text-Sound-Graphics layout while 20.4% had accessed content with all the elements integrated. Only 7.7% of the learners had accessed digital content with Sound-Graphics-Text kind of arrangement. Figure 4.12 summarises the layouts of the Biology digital content as highlighted by learners.

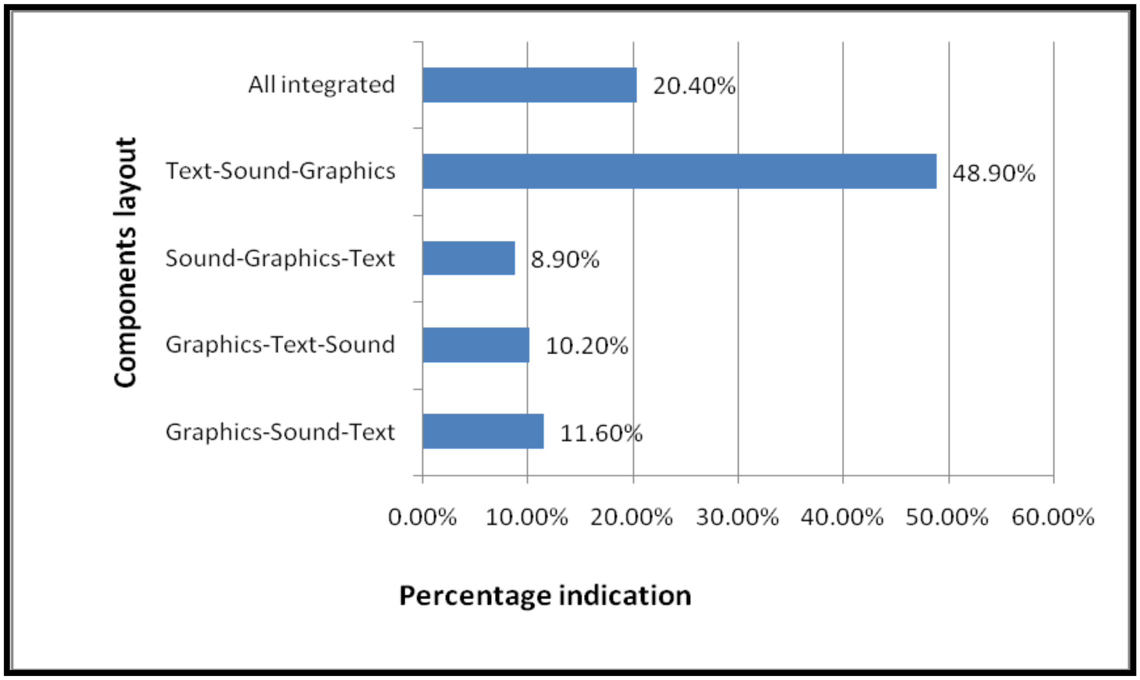

Figure 4.12: Biology content layout as indicated by learners

From these results, it can be observed that most of the digital content in the schools had the Text-Sound-Graphics layout. Only a small number of the content had an integrated kind of arrangement. Although teachers and learners presented different figures for different layouts, the trend is clear. Content with Text-Sound-Graphics layout is the most common while that with Sound-Graphics-Text is the least common. According to the cognitive theory of multimedia learning, human information processing system has two separate channels with limited capacities. SEG (2008) observed that when information is presented using both channels, the brain can accommodate more new information. Sweller (2005) also argued that when information is presented using both the visual and the auditory channels, working memory can handle more information overall. This means that content that presents visuals such as graphics and voiceover at the same time may be more effective for the instructional process as compared to the one that presents each element at a time.

As such, digital content that has all elements presented in an integrated way is likely to be more effective in the instructional process than the other layouts. Nugent (1982) obtained the highest learning levels when she presented information via combined text and pictures or combined audio and pictures compared to the same content presented via text alone, audio alone, or pictures alone. Najjar, (1998) while describing the principles of educational multimedia user interface design pointed out that, the information being presented in one medium needs to support, relate to, or extend the information presented in the other medium.

Developers therefore need to improve the layout of Biology digital content by ensuring that the multimedia elements are integrated while taking care to avoid cases of cognitive overload. This would be achieved by ensuring that qualified and experienced content designers and developers are involved in the digital content development process. Patti (2005) pointed out that determining when to use multimedia and designing good multimedia require real consideration and benefits from a team of people with instructional design, graphic arts, information architecture, and usability skills.

4.6.2 Navigational (primary) tools in the Biology digital content

Navigational tools are very important in any interactive digital content since they enable the user to manipulate the content. Najjar (1998) noted that consistent-looking and consistently placed navigation elements clarify what to do next. Jisc digital Media

(2013) pointed out that digital content interface should be designed in such a way that when using the content, it is always clear where you are and where you can go next. The user needs to be fully in control of their navigation and use of the content. It is therefore very critical to have proper navigational tools in any interactive digital content to enhance usability and learning.

The researcher therefore viewed the Biology digital content in schools to ascertain whether it had basic (primary) navigational tools that would enable the user to navigate through and easily utilise it while having full control. Among the navigational tools considered included play, pause, stop, next, previous and exit buttons. In addition, the form in which navigational tools were presented was considered. Most of the content viewed (78%) had the basic navigational tools such as play, pause and stop. Within the content that had navigational tools, 40.4% of the navigational buttons were presented in text, 42.1% iconic and 17.5% was a combination of icons and text. Where presentation was by icons, they varied from content to content making navigation a bit difficult. It is only 22% of the content that appeared to lack some basic navigational tools.

Teachers were also asked to give their opinion on the navigational tools available in the Biology digital content. In average, majority of them (78.48%) indicated that the Biology digital content they had accessed had the basic navigational tools. They also indicated that among the content with basic navigational tools, 48.75% of the buttons were presented in text form, 40.28% were iconic while 10.97% had a combination of icons and text. The types of icons used were differed from content to another. Table 4.17 gives the details on the navigational tools in Biology digital content as indicated by teachers. Navigational tools are part of user interface and hence this addresses the objective on the formulation of the curriculum digital content user interfaces.

Table 4.17: Navigational tools in Biology digital content according to teachers

Navigational tools	Percentage (%) availability		Form of presentation (%)		
	Yes	No	Text	Icon	Text & Icon
Play	79.1	20.9	51.3	38.7	10.0
Pause	80.6	19.4	45.6	43.1	11.3
Stop	79.1	20.9	47.2	40.7	12.1
Next	77.4	22.6	48.9	41.3	9.8
Previous	76.7	23.3	50.3	39.0	10.7
Exit	78.0	22.0	49.2	38.9	11.9

Learners were also asked to give their opinion on the navigational tools during the guided group discussions. Majority of them (78.57%) said that the content they utilised in Biology had the basic navigational tools. Most of these tools (72.83%) were provided in text form, 13.87% were icons while 11.03% was a combination of icons and text. The icons varied from content to content. The details of the navigational tools as observed by the learners are given on table 4.18.

Table 4.18: Biology digital content navigational tools according to Learners

Navigational tools	Availability		Form of presentation		
	Yes	No	Text	Icon	Text & Icon
Play	77.9	22.1	50.3	38.1	11.6
Pause	81.3	18.7	46.1	42.9	11.0
Stop	79.4	20.6	46.9	41.0	12.1
Next	78.0	22.0	50.0	41.5	8.5
Previous	76.9	23.1	50.1	38.9	11.0
Exit	77.9	22.1	48.9	39.1	12.0

Effective digital content for teaching and learning needs to be interactive and easy to navigate in order to have a positive influence in the instructional process. Mayer et al (2003) noted that learners learn more if they are able to control the pace of the presentation. Interaction is a mutual action between the learner, the learning system, and the learning material (Fowler, 1980). Najjar (1998) argued that an interactive user interface may allow learners to control, manipulate, and explore the material or periodically asks learners to answer questions that integrate the material. An interactive user interface appears to have a significant positive influence on learning from multimedia content (Fletcher, 1989, 1990; Stafford, 1990).

If digital content is not easy to navigate and use, then its level of interactivity is low which in turn reduces the utilisation and influence of such content in the instructional process. Interaction may improve learning because it encourages learners to elaborately process the learning material (Walker, Jones and Mar, 1983). From the results obtained on the navigational tools, it can be observed that most (78%) of the digital content viewed by the researcher had the basic navigational tools. This means that most of the Biology digital content in the schools was interactive and therefore had the potential of bringing positive influences in the instructional process if well utilised.

However, a small percentage (22%) of the digital content lacked basic navigational tools which are essential to the utilisation of the content. Digital content that lacks basic navigational tools such as play, stop and pause makes the user unable to control it. According to SEG (2008), multimedia presentations are more effective when the learner has the ability to interact with the presentation, by slowing it down, starting or even stopping it. In addition, the form of the navigational tools was not standard in Biology. Some navigational tools were given in text form, others iconic while some were presented in a combination of text and icons. This can make the content more complicated to users since one had to learn how to navigate the different types of content available in Biology. This is time consuming and may probably account for the number of Biology teachers who indicated that they had accessed Biology digital content but never used it for instructional process.

University of Oregon (2013) argued that for digital content user interface to be friendly, the primary navigation should be easily noticeable and standardized in appearance. The navigation tools should be easy to distinguish from other components of the content. Digital content developers need to consider coming up with *standard navigational* tools that will be used across all the curriculum digital content. These will make navigation of digital content easy since once you learn how to navigate through one type of content, you can easily navigate any other digital content. Engaging professional software engineers and content designers in the process of Biology digital content development could help achieve this.

4.6.3 Support (secondary navigational) tools in the Biology digital content

Support tools are very important in the utilisation of digital content. They help the user to easily search the parts of the content they are interested in, seek help in case they have difficulties using the content or even easily get the meaning of certain technical terms used in the content. Some of the support tools used in digital contents includes help, search and glossary. The Biology digital content in schools was analysed to ascertain whether it had such buttons. It was established that most of the content (88.3%) lacked these support tools. In some cases, they were provided but were inactive meaning they could not be used. In the few cases where these buttons were provided, 70% were in text, 11.3% iconic while 18.7% combined icons with text.

In their questionnaire, Biology teachers were also asked to indicate whether support tools were present and how they were presented in the digital content. Only 10.9%, 16.1%, and 9.4% of the teachers indicated that the Biology digital content they had interacted with had active search, help and glossary buttons respectively. Among the content with support tools, an average of 72.26% had presented them in text form, 14.10% was iconic while 13.63% combined the icons with text. Figure 4.13 gives a summary of the forms in which support tools in Biology digital content were presented.

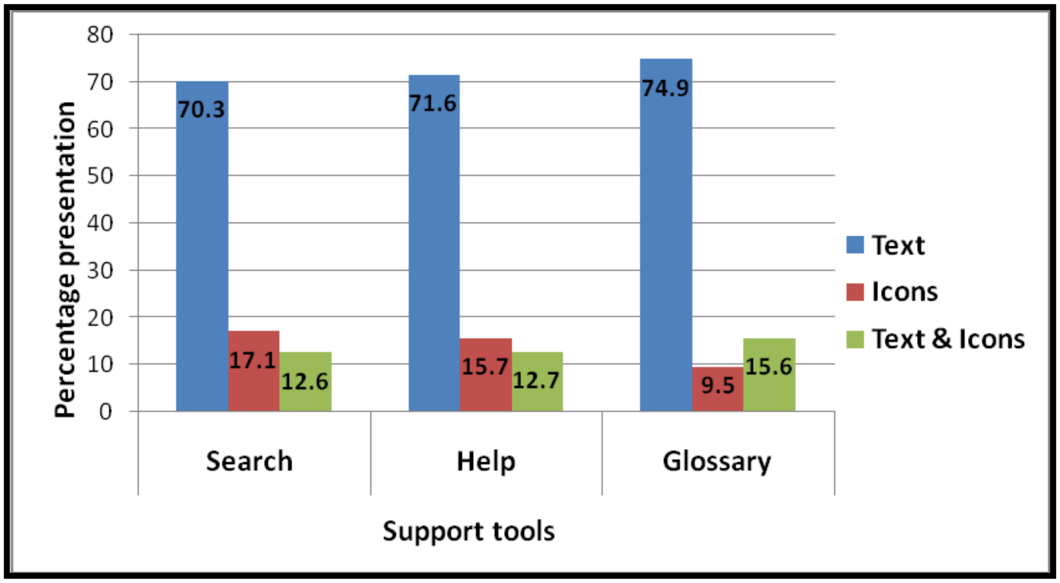

Figure 4.13: Support tools in Biology digital content as indicated by teachers

During the guided group discussions, learners were asked whether there were support tools such as search, help and glossary in the content they utilised. They were also asked about the forms in which tools were presented in the content. Most of the Biology digital content that learners had interacted with lacked active search, help and glossary buttons. It is only 9.1%, 11.9%, and 10.1% of the learners pointed out that the Biology digital content they had interacted with had active search, help and glossary buttons respectively. Among the content with support tools, an average of 72.83% had presented them in text form, 13.87% was iconic while 12.97% combined the icons with text. Figure 4.14 gives a summary of the forms in which support tools in Biology digital content were presented based on the learners' view.

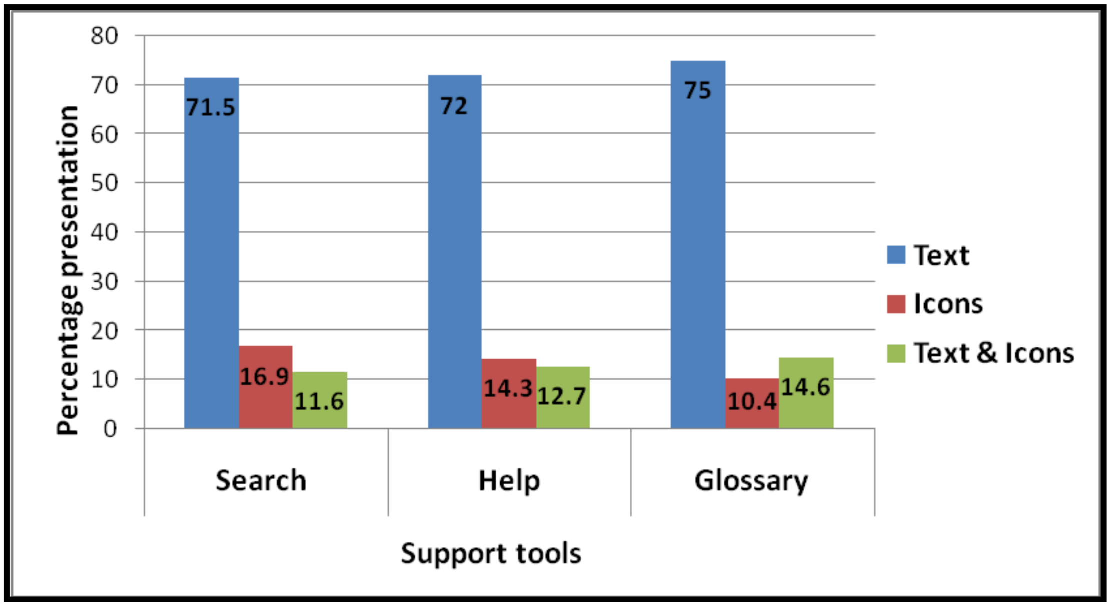

Figure 4.14: Biology digital content navigational tools as indicated by learners

Digital content needs to have support tools such as the search, help and glossary. These tools make the content easy to utilise. The tools should also be presented in a form that makes them easily recognizable by the user. Digital content that lacks such support tools may not be attractive to teachers and learners. In addition, use of unfamiliar icons for support modules may make the content unfriendly to the user. This may reduce the level of utilisation by both teachers and learners. As a result, the benefits that come with the utilisation of digital content may not be realised. Digital content developers should therefore ensure that support tools are incorporated in their content during development to make it easy to utilise. It would also be important to consider developing standard buttons for the support tools in all the curriculum digital content. This would reduce the time spent by learners and teachers trying to understand the ever-changing buttons used by different developers in different digital content.

4.6.5 User interface and the utilisation of Biology digital content

There are various aspects of digital content user interface that may influence the level of utilisation and effectiveness of Biology digital content in the instructional process. Some of these aspects include the layout of the content, navigational tools and the support tools in the content. During this study, teachers were asked to indicate whether the layout of content influenced their utilisation of Biology digital content. More than three quarters of teachers (92.3%) indicated that their utilisation of Biology digital content would be influenced by its layout. In the guided group discussion, a similar question was posed to the learners. An overwhelming majority (94.6%) were of the view that the way Biology digital content is organized affected their utilisation of the content. Teachers and learners argued that the organization of the content enhance the understanding of a concept. This is especially true if the multimedia content has the right layout that utilises the two channels of learning. SEG (2008) observed that by using multiple channels of the working memory, multimedia content can increase the likelihood that information will be effectively integrated into the long-term memory and not lost. In this regard, content that promotes better understanding of concepts will tend be utilised more by learners and teachers and has positive influence on the teaching and learning process.

Teachers and learners were also asked to indicate whether navigational and support tools provided in the digital content affected their utilisation of the content. Majority of the teachers (90.7%) and learners (96.5%) held that navigational and support tools would affect their digital content utilisation level. They gave the following reasons:

- Navigational and support tools make it easy to navigate through the content and therefore they utilised digital content with better tools more than digital content that lacked such tools.
- These tools give the user full control of the digital content, that is, you can control the pace of the content to facilitate understanding of a certain concept. In addition, you can start, stop, pause or even exit the content at any point.
- The help button gives them an opportunity to get assistance whenever they face difficulties making it easy to use such content.
- Support tools such as search makes it fast and easy to use the content since you can easily search the topic, subtopic or even a concept that you want to cover easily.
- Glossary helps them to easily get the meaning of technical terms used in the content without necessarily having to look for dictionaries.

This observation is supported by some scholars. According to Mayer and Sims (1994), multimedia content is more effective when learners have the ability to start and stop it at their own will and are able to manipulate it such that they learn at their own pace. Mayer and Chandler (2001) also argued that when provided with the ability to interact with the multimedia content by being able to control it through navigation tools, learners seem to enjoy the experience more and perform better when tested on the content. Stafford (1990) statistically analyzed 96 learning studies and concluded that interaction was associated with learning achievement and retention of knowledge over time.

Learners are more interested and enjoy using digital content with good navigational tools as suggested by Mayer and Chandler (2001). This increases utilisation levels of that particular digital content. Utilisation of the digital content has an influence on various aspects of the instructional process such as understanding of a variety of concepts, content retention, learners' motivation and even their attitudes as suggested by various scholars. Alfar (2009) observed that multimedia material help learners remember and transfer their knowledge. Clark and Craig (1992) suggested that multimedia materials offer motivational advantages in a learning process.

Well-designed multimedia material can enhance motivation, learning, and transfer (Patti, 2005). Teoh and Neo (2007) accentuated that Studies demonstrate that students who learn from multimedia have superior self-esteem and motivation. Consequently, the rate of content retention in multimedia learning exceeds that of traditional means. When learners are engaged in learning, the likelihood to retain information and sustain the learning process increases. Better and easier understanding of concepts, high content retention and improved learners' attitude and motivation will consequently lead to better syllabus coverage and improved scores by learners' in the assessment tests. It can therefore be concluded that the user interface employed by curriculum digital content has an influence on its utilisation and effectiveness in the instructional process.

4.7 Deriving a model for design and development of an effective Biology digital content

The final objective of this study was to derive a model for design and development of an effective Biology digital content for secondary school. The Association for

Educational Communication and Technology (AECT, 1977) defined a model as a simplified view of a complex reality or concept. A model is an abstract representation of reality (Twoli, Maundu, Muindi and Kithinji, 2007). It is a graphic or visual representation of a real-life situation either as it is or as it should be. Models hence help designers and developers to visualize the problem and break it down into discrete units that are manageable. This study thus sought to develop a model that would give stepwise guidelines to designers and developers of Biology digital content. To be able to derive a working model for design and development of an effective Biology digital content, the researcher considered some of the existing instructional and multimedia design models, the digital content design and development process in Kenya and some of the key findings of this study.

4.7.1 The process of Biology digital content design and development in Kenya

In the examination of the Biology digital content design and development process, this study considered various factors. Such factors include the stages of digital content development, resources involved in the development process, challenges faced by developers and ways of improving digital content development process. This was important to help identify areas of improvement in the development process to ensure that appropriate Biology digital content is produced. The information of the development process was obtained through interviews with the sampled digital content developers and designers. It was then recorded using the digital content developers' interview schedule. Consequently, the study came up with a model that could guide the development of appropriate digital content for Biology.

4.7.2 Stages of digital content development in Kenya

During the interview with digital content developers and designers, the study sought to establish the stages followed in digital content development. The researcher asked the digital content developers the steps they followed in digital content development process. To guide them, 15 stages of digital content development stages were suggested and the developers asked to indicate if they followed them during their content development process. They were then asked to give other steps they carry out in their digital content development process.

After analysis of the data provided by the content developers, the study discovered critical gaps in the curriculum digital content development process in Kenya. Some developers overlooked some of the very essential stages of content development such as assessment of learners and teachers content needs, piloting of the developed content, evaluation and vetting as well as monitoring and evaluation. Figure 4.15 shows a summary of the stages followed by various Biology digital content developers in percentage. The blue colour shows the percentage of the developers who undertook a particular stage while red indicates the ones who did not have such a step in their digital content development process.

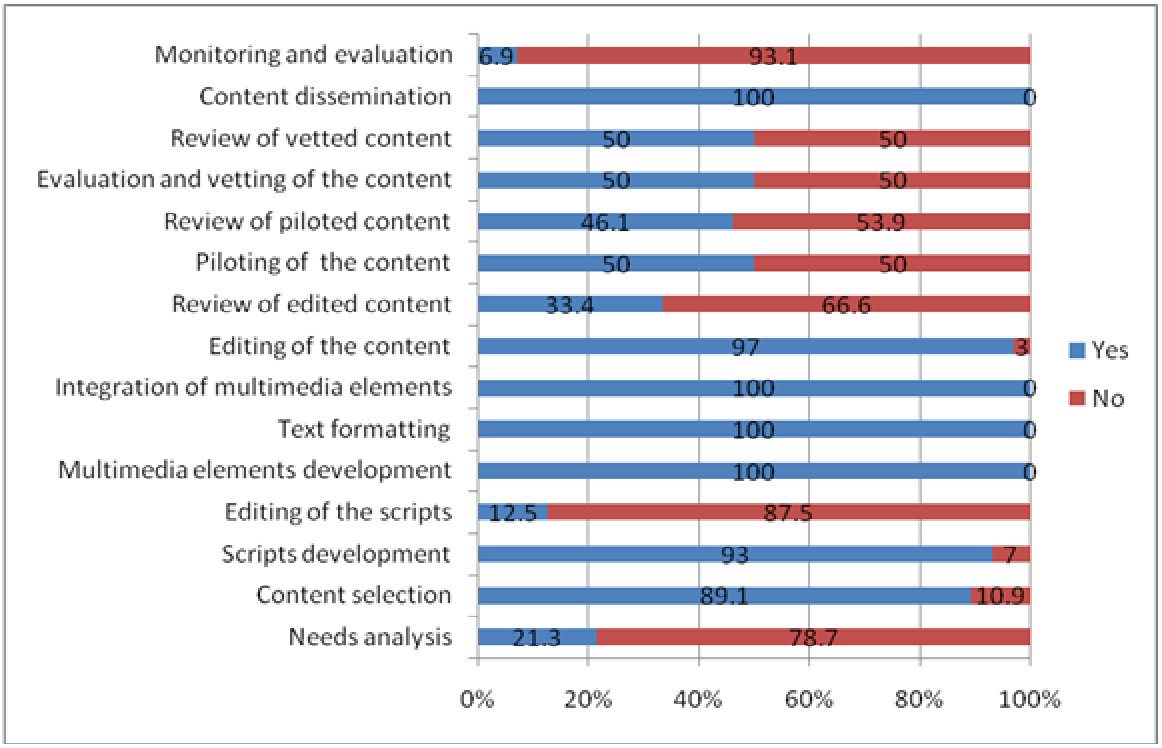

Figure 4.15: Summary of the stages followed in Biology digital content development

From these results, it can be observed that only 21.3% of the Biology digital content developers took time to analyse the needs of teachers and learners before embarking on the content development. Furthermore, only 50% of the content developers piloted their content before dissemination to schools. This situation is likely to lead to development of digital content that is not based on the learners' and teachers' needs. Some parts of this study had revealed a big difference in terms teachers and learners' preference and what is provided in the Biology digital content. For example, most teachers and learners preferred web-based content while most of the content provided in schools was computer based.

When it comes to multimedia elements, most teachers and learners were more interested on animations, videos and games while the Biology digital content mostly consisted of text, voiceovers and illustrations. The consequence of this is low utilisation of Biology digital content in the instruction process. This may therefore partly explain why this study found out that only (56.7%) of teachers had utilised Biology digital content in the instructional process in Nairobi County. It may also explain why 23.3% of Biology teachers had accessed Biology digital content yet they had never utilised it in the instructional process. KICD (2013) had also indicated that only 38% of the ESP schools were utilising the Institutes Biology digital content in the instructional process despite the fact that all ESP-ICT schools were issued with the content free.

Another more solemn revelation from these results is the fact that majority of the content developers did not edit content scripts or review their content after editing and piloting. Moreover, a considerable number of developers (50%) revealed that their content was not taken for evaluation and vetting neither did they do regular monitoring and evaluation of their content after dissemination. These steps are critical in any digital content development process because they reveal the weaknesses of the content giving the developers an opportunity to address them. These are basically the steps that should ensure quality of the digital content being developed. Some of the reasons given by teachers and learners as to why they do not utilise Biology digital content was that it is difficult to navigate, it was shallow and some parts of the content were not relevant to the syllabus. With proper editing, vetting, monitoring and evaluation, these weaknesses would have been noticed and corrected. This would have addressed the teachers and learners' concerns leading to improvement in digital content utilisation. The issues of digital content development process could be tackled by ensuring that all the critical stages in development are followed. To achieve this, it would be advisable to provide a research based model to guide digital content developers in the development process.

4.7.3 Resources involved in digital content development

Development of curriculum digital content is a lengthy and resource intensive process as it involves hardware, software and human resources. This study focused on the human resources since this dictates the kind of content to be developed and even the types of hardware and software to be used. This was achieved through interviews with Biology digital content developers. The developers were asked to indicate the persons involved in Biology digital content development and rate their level of involvement in a scale of 100. The level of involvement was based on the number of stages they are involved in during the digital content development process. Amid the persons listed included the content developers, graphic designers, video editors and teachers among others.

Content developers were the highest rated at 80% meaning they were involved in most of the processes of content development. It was further revealed that some stakeholders such as researchers, quality assurance officers and KNEC officers were not involved at all in Biology digital content development. Despite the fact that learners are the main target for the content being developed, they were among the lowest rated at 13% in terms of the level of involvement during the development process. Although all the developers indicated that they involved learners during development of the content, further probing revealed that learners were only involved in the piloting and dissemination stages. This means that learners' opinion was not sought during the actual development of Biology digital content. Figure 4.16 gives a summary of the persons involved in Biology digital development and their percentage rating based on the level of involvement in the process. The blue colour on Figure 4.16 shows the percentage of developers who involved a particular specialist while the red colour shows the percentage level of involvement based on the number of stages one is involved in the digital content development process.

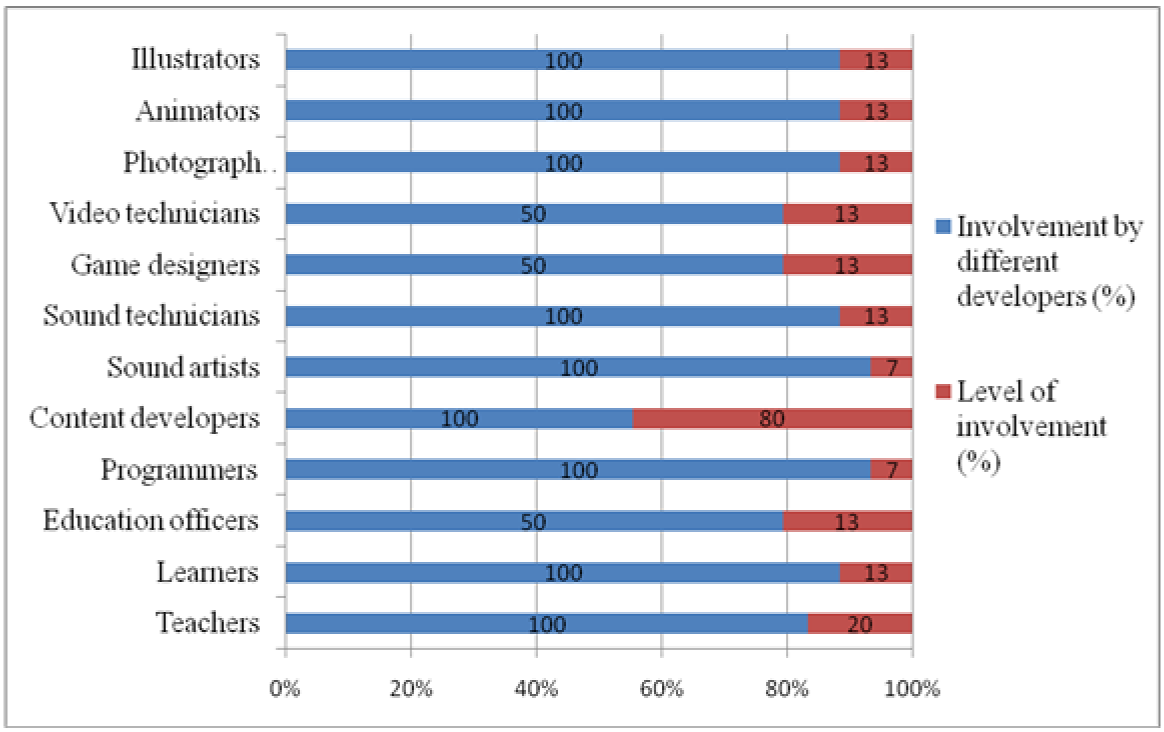

Figure 4.16: Persons involved in Biology digital content development

These results show that various specialists are involved in the process of developing Biology digital content particularly the teachers and learners who form the core of stake holders. However, lack of involvement of a number of critical officers may lead to development of low quality content. Researchers for example are very critical in assessing and analysing the needs of the learners and teachers before the actual development of the content begins. They are also very useful in monitoring and evaluation both during pilot testing of the content and after dissemination. Their reports should be able to reveal the strengths and weaknesses of the content giving the developers an opportunity to improve the content. This would improve both the level of utilisation of digital content and also its influence to the users.

Whereas researchers help ensure quality of the content mostly before and after development, quality assurance officers will help ensure quality during the process of development. They should be involved in various stages of content development including selection of the content, scripting, editing, reviewing, piloting and even dissemination. Script developers are also very useful in story bonding during content development. They are able to organise the content and ensure that the flow is consistent. Any other activity that follows during content development should be guided by the scripts. Poorly developed scripts will lead to development of low quality digital content.

It can therefore be generally observed that Biology digital content development is a lengthy process that requires a lot of human resource capability and devotion in addition to software and hardware. This makes it a very expensive and resource intensive affair. It may be because of this reason that developers opt to overlook some stages and even not involve some crucial officers during the development process. This results to development of digital content that has design issues that make it inappropriate for learners. Examples of such issues are inappropriate and low quality multimedia elements, poor navigation tools, unpopular content layouts and meagre dissemination modes. Consequently, utilisation of Biology digital content in schools is low and even those who utilise it do not reap the full benefit. This is evidenced by the low levels of utilisation of the digital content in ESP-ICT schools despite the fact that they are provided with the content freely by the ministry. The slight difference in achievement between the learners who utilise digital content and the ones who do not utilise provides further evidence. Omitting some development stages and not involving some critical persons in the process of development may however not provide a solution.

4.7.4 Challenges encountered in digital content development and proposed solutions

Biology digital content developers were also asked to indicate the challenges they encounter during development. Most of the developers submitted that they face a range of challenges during the development process. Some of the challenges as highlighted by digital content developers included the following:

- The process of Biology digital content development is resource intensive, ranging from ICT hardware such as computers to creative software such as adobe flash which are very expensive to acquire. In addition, a lot of human resource is required to undertake this process successfully.
- Development process is made of many stages which also require a lot of resources to undertake. Some of the stages include analysis of the content, scripting of the content, authoring the content and editing among others.

- Development of multimedia elements for the content requires a lot time and human resource. For example, animators to develop animations, illustrators to develop illustrations, sound artists to records the narration, sound technicians to edit the voiceovers, camera people to shoot the video clips and video technicians to edit the videos clips just to mention a few.
- Development of a digital content platform that is appropriate to learners is also a big challenge. Many of them indicated that it had taken quite some time to come up with the platforms they were currently using and even then, those platforms were not stable and needed frequent updating due to continuous change in technology.
- Meeting the learners and teachers demands in the digital content may be too expensive and tedious. They argued that the kind of multimedia elements such as animations that teachers and learners demanded were too challenging, time consuming and expensive to develop.
- Most developers felt that their content was not secure and could easily be pirated and distributed by other people to unsuspecting users. They disclosed that even with security systems available and copyrighting their content was still not secure.

The developers were then requested to propose solutions to these challenges. The following solutions were suggested:

- The government needs to subsidise the cost of hardware and software being utilised in development of curriculum digital content. Some of the hardware that needs subsidy includes computers, digital cameras, video cameras, editing suites etcetera. On software, creative software, operating systems, antivirus and content protection packages needs to subsidise. This would lower the cost of content development, motivating many developers to develop more content and also lead to affordable cost of complete digital content.

- The government can facilitate and make it easy for the developers to undertake some content development stages. For example, the government can give an umbrella licence to all developers to access various sites such as forests, game parks, game reserves, power stations, etcetera, when collecting data for development of curriculum digital content. This would hasten the process of digital content development making it less strenuous and lowering the cost of development.
- A central data base for multimedia elements that can be used in curriculum digital content needs to be developed. All the data that already exists such as historical video clips and photographs should be deployed in this database. This would leave the developers with task of only customising the multimedia elements that exist while only developing those that does not exist afresh. A neutral team can then be appointed to manage this database.
- A common standardised curriculum digital content platform needs to be developed and made free for access and utilisation in content development by any developer. This would reduce the cost of developing new platforms while standardising all the curriculum digital content.

- Proper copyright, patenting, plagiarism, privacy and data protection legislations, policies and mechanisms needs to be put in place to protect the work of curriculum digital content developers and therefore motivate the to do more development.

4.7.5 The Proposed curriculum digital content design and development model

This study found out that ESP-ICT secondary schools had access to Biology digital content that could be utilised in the instruction process. The content is interactive to some extent with most of the basic navigational tools such as play, pause, next and stop buttons availed. The content also has a variety of multimedia elements including text, sound, videos, animations, illustrations, photographs and games.

However, Biology digital content appeared to have design issues that limited its utilisation and influences in the Biology instructional process. Some of the key issues detected were in the dissemination mode, multimedia elements and the user interface. On the dissemination mode, majority of teachers and learners preferred online content while most of the Biology digital content was being disseminated offline. As per the multimedia elements, most teachers and learners preferred animations, video clips and games while the bulk of the Biology digital content in schools consisted of text, sound, photographs and illustrations. In addition, some of these multimedia elements lacked proper quality and combinations in the Biology digital content. On the user interface, most of the content had a text-sound-graphics layout while the most preferred and effective is an all integrated layout. Moreover, the interface in most of the Biology digital content lacked secondary navigational tools such as search, help and glossary. All these flaws point out to an inconsistent process of the content development.

The faults highlighted from the findings of this study suggest that there were weaknesses in the design and development process of the Biology digital content. For example, the difference between the teachers and learners' preference and what was provided in the digital content suggest that needs assessment was either not done or it was not comprehensive. This may also imply that the right experts were not involved in the development process leading to either omission of some crucial stages such as needs assessment or even doing them indecorously. Low quality and improper organization of some multimedia elements as well as lack of secondary navigation tools in the content also points out to lack of experts in some stages of the digital content development process.

A closer look at the process of the content development revealed some issues with developers omitting some critical stages and ignoring crucial persons during development to cut on the cost and time of digital content development. In the interview with various content developers, they revealed steps like needs assessment, piloting and evaluation are habitually omitted in a bit to reduce the cost of production and minimise the time taken to develop curriculum digital content. This has a negative influence on various aspects of the developed digital content and therefore an immediate intervention is required.

While acknowledging the need for proper strategies to be put in place to address these issues, some weaknesses could be tackled by having a standard curriculum digital content design and development model that could be accessed and used by all developers to guide them in the digital content development process. According to Frey and Sutton (2010), designing instruction can be an enormous task, and a model would provide a systematic structure for the process.

The findings of this study revealed that there were flaws in the process followed in content development, persons involved as well as the products such as scripts, multimedia elements and the final digital content. Keppell (2000) emphasized that the design and development of multimedia content requires a team with a diverse range of skills and talents to successfully complete all aspects of the content. He further argued that the design and development of quality multimedia learning materials often require instructional or learning designers to assist subject matter experts in creating suitable teaching and learning resources. It is therefore critical to ensure that experts of various areas are fully involved in the development of curriculum for development of more appropriate curriculum digital content.

A review of literature revealed that there are various instructional and multimedia design models that are already in place. It was also discovered that various scholars had come up with different models. As such, there was no standard model for instructional and multimedia design. Additionally, the study did not come across any curriculum digital content design and development model during this review. The instructional and multimedia models reviewed used different approaches and gave various steps that could be followed in the design of instructional and multimedia materials. For example, ADDIE model has five phases namely analyze, design, develop, implement and evaluate. Greer (1992) has ten steps while Dick, Carey and Carey (2001) had ten steps among others. Frey and Sutton (2010) observed that there was not a concise multimedia development model that was readily available to guide educators through the complex development process. Even within the business and industry, Barry and Lang (2001) found no uniform approach to multimedia development. The reviewed literature did not show any specific curriculum digital content design and development model in existence. This study hence attempts to come up with a model to guide development of curriculum digital content.

Based on the consideration of the findings of this study, the reviewed instruction and multimedia design models and curriculum digital content development process in Kenya, the researcher derived a six-stage digital content design and development model. The model adapts part of its framework from the ADDIE model of instruction design. ADDIE is an instructional design model which is valid for any kind of education (McGriff, 2000). Despite the fact that ADDIE comprises the components of all other design models, it is relatively simple (Kaminski, 2007). The various aspects of digital content design and development were then carefully infused in each and every stage of the model. According to Patti (2005), determining when to use multimedia and designing a good multimedia content require real consideration and benefits from a team of people with instructional design, graphic arts, information architecture, and usability skills. The model derived by this study therefore incorporates the specific experts who are expected to deliver every stage of the digital content development as well as the expected output.

Such a model should ensure that every stage of digital content development is intertwined with the relevant experts and the expected outputs to ensure that the process is incontrovertible. Consequently, all the critical stages of content development should be undertaken by the right experts who would be held accountable to provide the expected output that ought to move to the next stage of development. The model is thus named the **ESO digital content design and development model**. ESO is an abbreviation of *Expert*, *Stage* and *Output*. The ESO digital content design and development model has a feedback mechanism and provides avenues for quality checks in every stage while allowing a return to the previous stage of development to rectify any detected faults. The six main stages that make up this model include the following:

- Stage 1: Analyse
- Stage 2: Design
- Stage 3: Develop
- Stage 4: Implement
- Stage 5: Evaluate
- Stage 6: Revise

In the ESO model, each stage has several steps that are interrelated and have to be implemented by the specified experts to deliver a quality output. A review is carried out at every stage to ensure quality before the output proceeds to the next stage for further processing until the cycle is completed. There is a provision of returning the output to previous stage for further processing in case a review shows that the right quality was not achieved. After summative evaluation and continuous monitoring and evaluation, the content will be taken through a revision process depending on the improvements required. The details of each of the six stages of the ESO digital content design and development model are as follows:

Stage 1: Analyse

This stage basically entails setting up goals and objectives, undertaking the instructional needs analysis and content analysis and selection. In their instructional design model, Dick et al (2001) identified setting instructional goals, conducting instructional analysis and analysing learners' needs as some of the important steps that need to be considered when designing instructional programmes.

The findings of this study revealed that only 21.3% of the Biology digital content developers took time to analyse the needs of the teachers and learners before embarking on the actual content development. The study found out that there was a difference in terms of teachers' and learners' preference and what was provided in the Biology digital content in various instances. For example, teachers and learners were more interested on animations, videos and games while the provided content was dominated by text and sound. In addition, while 70% of the learners preferred online digital content, 50% of the developers indicated that they packaged and disseminated Biology digital content in offline formats only. This difference between the preference of the user and actual content provided may lead to low utilisation levels and non-realisation of the expected outcome. There is hence a need to analyse the needs of the user and set up goals and objectives before starting the concrete development of curriculum digital content so as to ensure the developed content meets the requirements of the users. This can be done in the first stage of the ESO model referred to as analyse.

During this stage, the instructional needs of learners and teachers are examined and analysed through interacting with them and getting their views. These needs and the requirement of the curriculum then enable the content designers and subject matter experts to come up with goals and objectives of the digital content. Using the syllabus and other reference materials, content is also analysed to determine what will be put into the digital format. The right content is then selected for a particular subject and level. This stage should involve educational researchers, content designers, multimedia designers, subject matter experts, policy makers and examiners. The expected output include goals and objectives, needs analysis report and the selected content.

Stage 2: Design

This stage of the ESO model takes the information compiled from the analysis phase to build the outlines and designs of the digital content to be developed. A review of the digital content development process in Kenya did not clearly outline the stage when multimedia designs and the technical and user interfaces are developed. However, an analysis of the Biology digital content accessed and utilised in the study schools revealed that it comprised of various multimedia elements namely text, sound, animations, illustrations, videos, photographs and games. The digital content was also presented in different types of user interfaces. The content presented in text and audio needs to be scripted. Scripting involves developing a kind of digital content outline based on the information obtained from the analysis stage. Further, designs for the multimedia elements and even the digital content user and technical interfaces should be developed. In his ten step, instructional design model, Greer (1992) referred to a similar step as *creation of a blue print* which involves developing a detailed outline of content, creating a summary of the media and materials that need to be created among other aspects.

This stage therefore involves development of the content scripts and designing of technical interface and user interface. It also involves developing designs and templates for multimedia elements and games. These scripts and designs are critical since they guide the content developers and multimedia developers during the development stage. Computer programmers or software engineers, games designers and multimedia designers should be involved in this stage. In addition, content designers, subject matter experts and script writers' needs to be involved. The expected outputs are the technical and user interface designs, multimedia and games designs and templates and subject content scripts.

Stage 3: Develop

Once the scripts and designs are completed in the design stage, they are actualised in the development stage. All the digital content developers interviewed indicated that they had development stage in their content development process. Among the activities that the curriculum digital content developers included in this stage were development of multimedia elements, text formatting and integration of the developed multimedia elements into the delivery platform. Care should however be taken to ensure that high quality elements are developed from the designs obtained. An assessment of the multimedia elements in the Biology digital content revealed that some of them, for example illustrations, had quality flaws. Similarly, the development of the user interface should be based on the designs made from the information obtained in the design stage.

In the ESO model, this stage will involve development of the user and technical interface as per the designs. Different multimedia elements including animations, illustrations, sound, text, video clips and photographs are then developed guided by the content scripts and multimedia designs and templates. This is followed by assembly of all the various elements that have been developed to form digital content. The content is then edited to ensure that it is factual and consistent with the set curriculum. This stage involves multimedia designers, subject matter experts such as teachers, voice artists and technicians, content designers, and video technicians. The expected outputs include animations, photographs, illustrations, video clips, voiceovers, sound effects, games, activities and text media files and assembled digital content. It is at this stage where the first draft of the complete digital content is obtained.

Stage 4: Implement

The complete curriculum digital content from the *develop* stage is utilised in the *implement* phase. During this period, learners who are the target group for the curriculum digital content get to interact with the developed content. The first part of this stage involves piloting of the digital content. At this level, teachers and learners are allowed to interact with the content and give their feedback. Digital content is then reviewed based on this feedback and then released for actual utilisation in the instruction process. Piloting and review of piloted digital content are very critical in the curriculum digital content development since they help the developers to identify and correct any flaws in the content. Moreover, feedback from learners and teachers is received at this level, and hence their views are incorporated in the final version of the digital content.

During interviews with the curriculum digital content developers, only 50% of them indicated that they piloted their content before the actual roll out. In addition, just 46.1% of the digital content developers reviewed the piloted curriculum digital content. This means more that 50% of the curriculum digital content developers never received nor incorporated the leaners and teachers view into their content before the final roll out. The faults that were detected in some of the digital content accessible in the study schools is thus likely to have resulted from the omission of the piloting and the review steps. On the same vein, this may account for some of the differences between the teachers and learners' preferences and the actual provision in the digital content. This stage should involve content designers, multimedia designers, education researchers and the users. The expected outcomes in this stage are reviewed curriculum digital content, the pilot, dissemination and utilisation reports.

Stage 5: Evaluate

This is one of the most important stages in the curriculum digital content development process since it ensures appropriate quality of the content. It provides an opportunity for the digital content developers, digital content evaluation experts and the users to examine the digital content and give their feedback. An examination of the digital content development process in Kenya revealed that a number of steps meant for this quality check stage are omitted by some developers during the digital content development process. During the interview with the digital content developers, a whopping 93.1% indicated that they never did any monitoring and evaluation of their content after dissemination. A further 50% never submitted their content for vetting and evaluation process while a similar percentage never reviewed their digital content after vetting. This implies that more than 50% of the digital content accessible in the schools has not gone through the necessary quality checks and therefore the existing weakness are not rectified.

The analysis of the digital content accessible in the study schools revealed some gaps such as lack of some navigational aids like search, help and glossary. There were also issues with content layout and organization of multimedia elements in some cases. In the questionnaire, teachers pointed out a number of weaknesses in the Biology digital content. Among the issues they raised was the difficulty to navigate through the digital content, shallowness of the digital content and non-relevance of some parts of the content to the Biology syllabus. Similar concerns were raised by learners during the guided focus group discussions. To ensure that such quality issues of the curriculum digital content are addressed, thorough vetting, monitoring and evaluation of all the digital content is necessary. This would also address the teachers and learners concerns and lead to development of more appropriate curriculum digital content. This would in turn lead to improvement in digital content utilisation in the instructional process.

In the ESO model, *evaluate* stage involves reviewing the outputs of every stage to ensure quality. After the content is completed, a summative evaluation is done along some set guidelines by qualified digital content evaluators. Once the content is released for utilisation, continuous monitoring and evaluation of its use is also done. Any flaws in the content should be noted and addressed to ensure that digital content in the schools is always up to date. Education researchers and content designers need to be involved in this stage. The expected outputs are the user feedback, monitoring and evaluation reports and recommended updates and upgrades.

Stage 6: Revise

This stage gives room for continuous improvement of the curriculum digital content. An assessment of the digital content development process in Kenya revealed that only 50% of the curriculum digital content developers reviewed their content after the vetting and evaluation process. No review was noted among the digital content developers after monitoring and evaluation process. On the same vein, a number of instructional design models reviewed by this study did not have the revise stage. ADDIE for example which is one of the most popular instructional design models lacks the revise stage. Greer (1992) and Morrison, Ross, Kemp and Kalman (2007) also omitted this step in their instructional design models. However, Dick, Carey and Carey (2001) have a revise phase after formative evaluation in their ten-step instruction design model. The revise stage is very important in any digital content development since it ensures high quality of the content. It is in this stage where recommendations of the users and evaluators are implemented. Any changes in technology and content are also taken care of in this stage.

In the ESO model, this stage involves implementation of the recommendations made in the *evaluate* phase. Digital content is reviewed based on the formative, summative and the continuous monitoring and evaluation reports. Enhancement is then done on the stage of the content development that is found to have led to the flaws. A newer enhanced version of the digital content is then packaged and disseminated for utilisation. The experts required and the expected output will depend on the stage where revision will take place. ESO digital content design and development model is summarised on figure 4.17.

ESO digital content design and development model

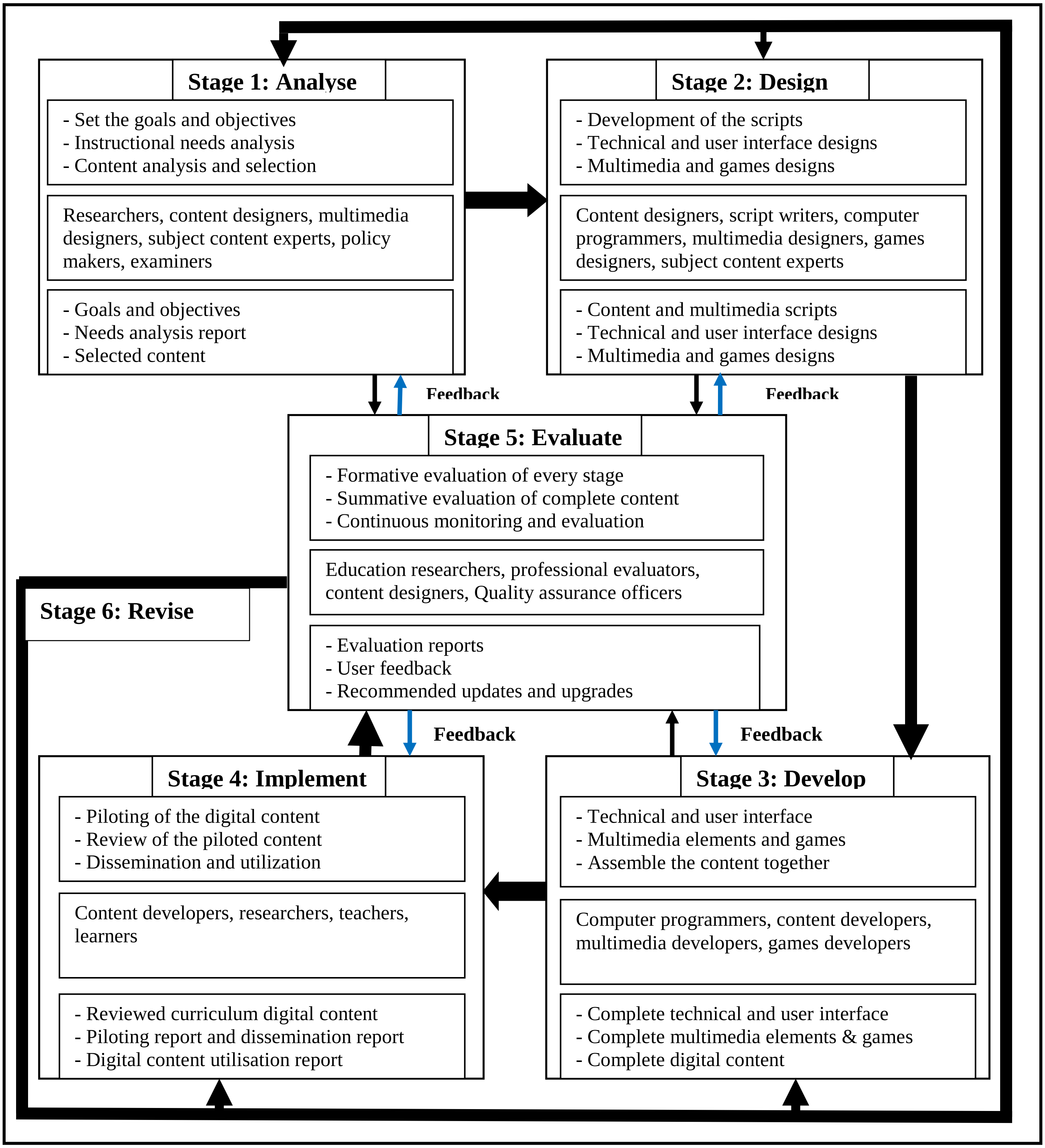

Figure 4.17: Proposed digital content design and development model

All the six stages in this model are interdependent and interrelated in the sense that each stage leads to the next one and in case a fault is noted, a product can be taken back to the previous step for review. Although part of the framework of ESO design model was adapted from ADDIE model, it is different in a number of ways including the following:

- ESO model consists of six development stages including analyse, design, develop, implement, evaluate and revise while ADDIE has five phases.
- Formative evaluation will be carried out after the completion of every stage, summative at the end of the whole process while monitoring and evaluation will be continuous to maintain high quality and continuous update and upgrade of the curriculum digital content.
- Specific experts will be involved in every stage of the curriculum digital content development to ensure development of appropriate digital content with high quality multimedia elements and suitable user interface.
- The output of every stage will be clearly set out and should be delivered and reviewed for quality before the process can proceed to the next stage.
- ESO model provides a channel for revision of digital content after summative evaluation and during continuous monitoring and evaluation to improve the quality of the curriculum digital content developed.

The summary of the findings, conclusions and recommendations of this study are provided in the next chapter.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study, summary of the research findings, implications of the findings for practice, conclusions made in accordance with the results obtained, recommendations for implementation and suggestions for further research.

5.2 Summary of the study

The purpose of this study was to investigate the influence of the utilisation and design of curriculum digital content on the Biology instructional process among secondary schools in Nairobi county, Kenya. The study was guided by five specific objectives including to: establish secondary school learners' and teachers' utilisation of curriculum digital content in the Biology instructional process, determine whether utilisation of secondary school curriculum digital content influences the Biology instructional process, analyse the nature, and influence of curriculum digital content multimedia elements on the secondary school Biology instructional process, examine the formulation, and influence of curriculum digital content user interface on the secondary school Biology instructional process and derive a model that can guide the design and development of an effective digital content for secondary school Biology curriculum.

This study was based on the Cognitive Theory of Multimedia Learning which was proposed by Mayer in 2001. This model was considered appropriate for this study since it dealt with the influence of curriculum digital content which delivers content in both pictorial and audio formats thus utilising both visual and auditory channels as highlighted by the model. The study employed a mixed methods approach where the triangulation design was applied. Use of triangulation design was to ensure that both qualitative and quantitative data which were essential for the research problem was obtained.

Secondary school Biology teachers, Form Three Biology learners drawn from fifteen ESP-ICT phase I secondary schools and digital content developers from two digital content development institutions whose Biology digital is approved by KICD in Nairobi county formed the target population for this study. In total, 1, 706 respondents formed the target population for this study. A proportionate sample size of 300 Form Three Biology learners, 30 Biology teachers and 10 digital content developers was used for this study. Data was collected from all the respondents in the sample size using six instruments which included Biology Teachers Questionnaire, Learners Focus Group Discussion Guide, Biology Teaching and Learning Resources Inventory, Digital Content Analysis Sheet, Documents Analysis Sheet and Digital Content Developers Interview Schedule. It was then analysed using both descriptive and inferential statistics with the help of SPSS version 20.0 and presented tables, notes, numerals and figures.

5.3 Summary of the main findings

In this segment, a summary of the findings of the study is presented in five sub-headings. These include: teachers and learners' utilisation of Biology digital content in the Biology instructional process, influence of utilisation of curriculum digital content on the Biology instructional process, nature and influence of curriculum digital content multimedia elements on the Biology instructional process, formulation and influence of curriculum digital content user interfaces on the Biology instructional process and deriving a model for development of more effective curriculum digital content.

5.3.1 Teachers and learners' utilisation of curriculum digital content in the Biology instructional process

This segment provides the answer to the question; do secondary school learners and teachers access and use curriculum digital content for Biology instruction? The data for this section were collected by use of the Biology teachers' questionnaire, the learners' focus group discussion guide and the Biology teaching and learning resources inventory. The main focus of this section was to find out if teachers and learners actually accessed and used Biology digital content in the instructional process. Among the factors considered included access and use of the Biology digital content in the instructional process, areas of utilisation of Biology digital content in the instructional process, formats in which the content is accessed, preferred formats of access, devices used to access the content and devices used for the storage of the content.

On the access and use of Biology digital content in the instructional process, 80% of the teachers in the study schools had accessed Biology digital content from various sources. However, 23.3% of the teachers who had accessed this content hardly used it for instructional purposes. Furthermore, 20% of the teachers involved in the study had never accessed Biology digital content. This means that 43.3% of teachers had not utilised Biology digital content for instructional purposes. This is despite the fact that all the teachers involved in the study were sampled from ESP-ICT phase 1 secondary schools.

These schools were provided with necessary ICT infrastructure for utilisation of digital content by MoEST and digital content by KICD in the year 2010/2011. With the provided ICT infrastructure, it was also possible to access and use Biology digital content from other developers since the schools were also provided with connectivity. The Learners involved in this study had equal utilisation and non-utilisation levels since they had been purposively selected to enable comparison of the two groups.

An assessment of the study schools revealed that they had ICT infrastructure such as ICT integration laboratories, computers, LCD projectors and the digital content packaged in computer based formats. Teachers and learners gave various reasons for non-utilisation of the Biology digital content in the instructional process. Some of the reasons included non-availability of the digital content for utilisation since it was normally locked up by institution administrators, difficulty in navigation of the content due to unclear or unavailable navigational and support tools, inappropriateness of the available content for instruction since it does not cover the syllabus well and incompatibility of the available digital content with the computers in the schools due to the high specifications required to run the content.

On areas of utilisation of Biology digital content in the instructional process, both teachers and learners indicated that they utilised Biology digital content in various ways during the instructional process. About 34.2% of teachers and 37.7% of learners pointed out that they utilised the digital content for revision purposes. This percentage is larger compared to 23.7% of teachers who utilised the content for actual content delivery and 30.4% of the learners who utilised the content for personal studies. This was most likely because of the type of digital content that was available in the schools. An assessment of the digital content in schools revealed that majority of the schools had revision and general reference digital content. Revision materials are generally shallow while general reference does not cover the entire syllabus making the two types of materials not preferred for actual content delivery and syllabus coverage.

Other ways in which digital content was utilised by teachers included preparing for lessons and assessment of learners. On the other hand, learners also utilised digital content for handling assignments and for general knowledge. It is therefore evident that digital content was available in different formats in the study secondary schools. In addition, some teachers and learners were able to access and utilise the content in various instructional areas using devices such as computers among others. However, some teachers and learners never accessed or even utilised the digital content in the Biology instructional process. This may have resulted from various challenges including formats and types of the Biology digital content that was availed, access and storage devices.

On the digital content access formats, 60% of teachers and 73.3% of learners had accessed computer-based Biology digital content. This is mainly because the content provided to ESP-ICT schools by MoEST was computer-based packaged in DVDs. In addition, most digital content developers package and disseminate digital content in computer based formats. An assessment of digital content developers revealed that 50% digital content developers packaged content in computer based formats only. However, 40% and 70% of learners preferred web-based digital content. This is mainly because online digital content is easy to access anywhere, anytime with internet connectivity. In addition, 36.7% of teachers and 6.7% of learners preferred content disseminated in both online and offline modes. Content available in both formats is easier to access since it is accessible with or without internet access. Content developers should therefore ensure that they package digital content in both computer-based and web-based formats to improve the level of access and utilisation of the content in the Biology instructional process.

As for the devices used for access and storage of the digital content, 59.1% of the teachers and 40% of learners used computers for content access. Among content storage devices, 24.8% of the teachers and 24.1% of the learners indicated they DVDs were the most common mode of storage of the Biology digital content. The main factor that might have contributed to this scenario is the fact that the content provided to ESP-ICT schools was packaged in DVDs. In addition, those schools were provided with resources to acquire computers and develop ICT integration laboratories. Computers are generally less portable compared to hand held devices such as tablets and smart phones. DVDs are also less portable as compared to flash disks and memory cards. In most schools, computers were kept and locked in the ICT integration laboratories making them inaccessible to teachers and learners when required for the instructional process. Despite the fact that the trend currently is cloud computing, very few teachers and learners indicated they accessed digital content from the cloud. Cloud would be the most appropriate digital content storage space due accessibility. Poor storage of the content limited accessibility and consequently utilisation of the digital content in the instructional process.

5.3.2 Influence of utilisation of curriculum digital content on the Biology instructional process

This section answers the question; how does the utilisation of secondary school curriculum digital content influence the Biology instructional process? In addition, the section seeks to address the null hypothesis; utilisation of secondary school curriculum digital content has no influence on the Biology syllabus coverage and utilisation of secondary school curriculum digital content has no influence on the learners' achievement in Biology. Data were collected using the Biology teachers' questionnaire, the learners' focus group guide and the documents analysis sheet. Three aspects in the Biology instructional process were considered including syllabus coverage, learners' assessment and the achievement. Teachers and learners were asked whether utilisation of Biology digital content had any influence on syllabus coverage. A considerable number of teachers (63.4%) and learners (77.3%) recorded that use of digital content enhances understanding of difficult concepts and could improve the pace of syllabus coverage.

Records of work were then analysed to find out whether there was any difference in the number of syllabus topics covered between the group that utilised Biology digital content and the one that did not. The number of Biology topics covered by the learners in the study groups while they were in Form One, Two and Three were recorded. The means were computed for the two groups and then compared using a two-sample t-test at 0.05 level of significance. The results revealed that there was no statistically significant difference in syllabus coverage between the two groups. This implies that utilisation of curriculum digital content had no influence on coverage of Biology syllabus contradicting the opinion of the majority of teachers and learners. Null hypothesis which stated that; utilisation of secondary school curriculum digital content has no influence on the Biology syllabus coverage was accepted. This could however have resulted from various factors including the fact that most of the digital content in schools was revision and general reference and therefore it was not preferred by teachers for use in actual content delivery in classroom which mostly determine syllabus coverage. In addition, navigation issues in the digital content such lack of secondary navigation tools in some content might have derailed the rate of utilisation of this content in the instructional process.

On the learners' assessment, teachers were asked whether use of curriculum digital content had any influence on the learners' assessment. Largely, 56.7% of teachers indicated that learners' assessment would be positively affected by the utilisation of digital content. A Likert scale with a list of items was then used to get the teachers opinion on some factors related to learners' assessment. These factors included frequency of assessment, variety of test items, feedback duration, adequacy of assessment and interactivity of the assessment.

Teachers indicated that use of digital content in the instructional process had improved the frequency of learners' assessment, provided more of test items and provided immediate feedback. In addition, digital content made Biology assessment more interactive and interesting to learners. They however thought that the available digital content did not provide adequate assessment to the learners. On the other hand, learners indicated that digital content enabled them to assess themselves, provided them with immediate feedback, made assessment more interesting and enable them to take control of their own assessment. Both teachers and learners were therefore in agreement that many aspects of assessment improved with utilisation of digital content in the instructional process. Improvement in classroom assessment makes a strong contribution to improvement in learning as observed by Black et al (1998).

On the utilisation of Biology digital content and learners' achievement, 52.1% of teachers and 73.3% of learners thought that use of curriculum digital content may lead to better scores in Biology tests. They argued that Biology digital content enhanced understanding of difficult concepts, promoted content retention and stimulated learners' interest in the subject. A comparison of the means of the Biology achievement between the groups that utilised Biology digital content and the ones that did not was then done using a two-sample t-test at 0.05 significance level. The results revealed a statistically significant difference between the two groups. This implies that utilisation of curriculum digital content has a positive influence on the achievement of learners in Biology tests. The null hypothesis that stated that; utilisation of secondary school curriculum digital content has no influence on the learners' achievement in Biology was rejected. These results are consistent with the findings of Fraser and Walberg (1995), Ayere et al (2010) and Jesse et al (2014) use of ICTs resulted to better learners' performance.

5.3.3 Nature and influence of curriculum digital content multimedia elements on the Biology instructional process

This section seeks to answer the question; how does the nature of curriculum digital content multimedia elements influence the secondary school Biology instructional process? Data were collected using the digital content analysis sheet, Questionnaire for Biology teachers and the learners' focus group guide. The section focused on the types of multimedia elements used in the Biology digital content, the extent to which these elements are used, the interest of learners and teachers based on the multimedia elements, the quality of the multimedia elements and how multimedia elements influenced the utilisation and effectiveness of the Biology digital content.

An analysis of Biology digital content revealed that it consisted of various multimedia elements including text, sound, animations, illustrations, video clips, photographs and games. The elements were in different proportions depending on the developer and the type of digital content. Most of the Biology digital content had all the seven multimedia elements but text and sound had the highest proportion. In some cases, the content lacked proper combination of multimedia elements whereby the elements were presented independently. This way, the working memory would process the visual and audio information separately. According to Sweller (2005), using multiple channels can increase the amount of information that the brain can process. In addition, these two channels process information quite differently, so the combination of multiple media is useful in calling on the capabilities of both systems. Meaningful connections between text and graphics potentially allow for deeper understanding and better mental models than from either alone (Patti, 2005). Effective multimedia for learning requires carefully combining media in well-reasoned ways that take advantage of each medium's unique characteristics. Appropriate curriculum digital content therefore should have different multimedia elements well combined in good proportions to make it interesting and have the right influence in the instructional process.

Rating by teachers and learners revealed that text and sound dominated the Biology digital content available in the schools despite the fact that the two elements are not interactive. They rated video, animations and games as the least common in the Biology digital content. However, 70% of the teachers rated animations as most interesting followed by games at 63.4% and videos with 56.7%. The bulk of learners (60%) rated videos and games as the most interesting followed by animations at 56.7%. Most teachers and learners rated text and sound as not interesting despite the fact they dominated the Biology digital content in schools. When less interesting components dominate the digital content, the content becomes unattractive to the user. As a result, the level of utilisation of digital content decreases and consequently the benefits of digital content utilisation are not realised. It is therefore critical for content designers and developers to increase the proportion of interesting multimedia elements while decreasing the less interesting ones in the digital content. This would in turn make the content more interesting to the user and thus increase their utilisation levels. This could be achieved by proper assessment and analysis of the learners needs before the actual development of the digital content. Involvement of the right specialists in the process of digital content development such as experienced teachers and multimedia designers would help to improve the proportions of the multimedia elements in the content.

Teachers also rated the quality of multimedia elements in the Biology digital content based on the clarity, relevance, audibility and harmonization of the elements. Majority of the respondents (81.8%) felt that the photographs were clear and relevant to the topical areas. However, 18.2% of the teachers felt that captioning, labelling and colouring of photographs needed to be improved. Most teachers (68.1%) agreed that sound was clear, audible and relevant to the topical areas. Some teachers nevertheless argued that the pace of the narration was fast for the learners, there was some background interference and it was not well harmonized with text and other multimedia elements in some instances. A significant percentage (68.2%) of teachers indicated that video clips were clear, of the right pace, had logical flow of images and were relevant. An overwhelming majority of teachers (90.9%) stated that the videos in the Biology digital content were relevant to the topical areas. Nonetheless, some teachers (31.8%) pointed out that some parts of the videos were blurred.

All the teachers agreed that illustrations were in the correct colour, proportions and were relevant but some felt that illustrations were not well captioned and images were not very clear. On the animations, 86.3% of teachers indicated they were clear, well harmonized with text and sound and relevant to the topical areas. In general, most of the multimedia elements in the Biology digital content were rated to be of good quality. However, a number of areas such as captioning, labelling and colouring of illustrations, pace and harmonization of sound, sharpness of images in video clips and captioning of illustrations needs to be enhanced. This would improve the quality of digital content consequently improving its effectiveness in the instructional process.

On the influence of multimedia elements on content utilisation, majority of teachers (93%) and learners (97%) indicated that their level of utilisation would be affected by the type, quantity and the quality of multimedia elements available. Teachers pointed out that, multimedia elements make content more interesting, enhance understanding of difficult concepts and improve the rate of content retention. Digital content with a variety of multimedia elements in the right proportions and of the right quality has a high rate of utilisation by both teachers and learners. Its utilisation is also much more likely to have a positive influence on the instructional process. Form Three Biology digital content in the study schools was found to have a variety of multimedia elements of relatively good quality although there were a few design issues such as the clarity of illustrations and harmonization of video clips and animations to text and sound.

5.3.4 Formulation and influence of curriculum digital content user interfaces on the Biology instructional process

This section answers the question; what influence does the curriculum digital content user interface have on the secondary school Biology instructional process? Data were obtained by use of Biology teachers' questionnaires, learners' focus group guides and the digital content analysis sheets. Various elements of the user interfaces of the

Biology digital content were considered. These included content layout, navigational and support tools in the content and their influence on digital content utilisation.

During content analysis, it was observed that Biology digital content was organised in five different layouts. These layouts included graphics-sound-text, graphics-text-sound, sound-text-graphics, text-sound-graphics and all the three integrated. From the digital content analysed by the researcher, 49.1% had text-sound-graphics while only 19.7% had an integrated interface. Among the teachers involved in the study, 46.1% indicated they had interacted with digital content that had a text-sound-graphics layout. Only 22.2% of teachers indicated that they had accessed Biology digital content with all the three aspects integrated. A greater percentage of learners (48.9%) had also accessed text-sound-graphics kind of digital content as opposed to other layouts such as the integrated one which had been accessed by only 20.4% of the learners. When the three aspects are presented separately as was the case with most of the digital content in the schools, it may not be very effective in the instructional process. Sweller (2005) and SEG (2008) argued that when information is presented using both visual and auditory channels, the brain can accommodate more new information. This therefore means that digital content that presents visuals such as graphics and voiceovers at the same time is likely to be more effective in the instructional process as compared to the one that presents each element at a time.

Biology digital content was also viewed to find out whether it had the basic navigational tools such as play, pause, stop, next, previous and exit. Most (78%) of the digital content viewed by the researcher had the basic navigational tools presented in text, icons or a combination of both. Where the presentation of the tools was by icons, the type of icons used varied from content to content. A similar percentage of teachers (78%) and 78.5% of learners also indicated that most of the content they had accessed had the basic navigational tools presented in the three different forms. Only a small percentage (22%) of the digital content viewed or even accessed by teachers (22%) and learners (21.5%) lacked the basic navigational tools. The variation of navigational tools from content to content, disparity of the icons used for navigational tools and lack of the navigational tools in some content made it a bit difficult for users to navigate through the digital content. This could therefore have lowered the level of utilisation and influence of the Biology digital content in the instructional process. SEG (2008) pointed out that multimedia presentations are more effective when the user has the ability to manipulate them. According to University of Oregon (2013), digital content user interface is friendly when the primary navigation is easily noticeable and standardized in appearance.

Biology digital content in schools was also analysed to ascertain whether it had secondary navigational tools such as help, search and glossary. It was established 88.3% of the digital content lacked such tools. Teachers and learners and learners also confirmed that these buttons lacked in most of the Biology digital content they had accessed. In some cases, these buttons were provided but they were inactive. In cases where they were available and active, the buttons were in different forms including text, icons or a combination of both depending with the digital content. Lack of secondary navigational tools or even use of varied icons makes the digital content unattractive and unfriendly to the user. Consequently, the level of utilisation and its effectiveness in the instructional process is low.

During the study, teachers and learners were asked to indicate whether the user interface of the digital content may affect their utilisation. An overwhelming majority of the respondents, 92.3% of teachers and 94.6% of learners indicated that their utilisation of digital content would be influenced by the content user interface. They argued that the organization of the content enhanced the understanding of the concept. Most teachers (90.7%) and learners (96.5%) were of the opinion that navigational and support tools would influence their utilisation of digital content. They indicated that navigational and support tools make it easy to navigate and utilise the digital content. These tools give the user full control over the content. This way, users can control the pace, start, stop, pause, search, get meaning of various terms or even exit the content at any point. This agrees with Mayer and Sims (1994) and Mayer and Chandler (2001) who observed that learners enjoy and use content more effectively when they are given the ability to control and manipulate the content.

5.3.5 Deriving a model for design and development of effective curriculum digital content

This section sought to answer the question; what kind of a model can be put in place to guide the design and development of effective digital content for secondary school Biology? To derive the model, the researcher considered data from the digital content design and development process in Kenya, existing instructional and multimedia design models and the key findings of this study. Data on the development of curriculum digital content in Kenya was obtained through interviews with the sampled digital content developers and recorded using interview schedules. Information on the existing instructional and multimedia design models was obtained through a literature review. Consequently, the study came up with a model that could guide the development of appropriate digital content for Biology.

On the digital content design and development process, the study revealed that some developers omitted some critical stages necessary for development of quality curriculum digital content. Some of the stages that are commonly overlooked included analysis of teachers and learners needs, piloting of the developed digital content, evaluation and vetting of the content and monitoring and evaluation. If needs analysis is not properly done, then the resulting content may not be based on the learners and teachers' interests. This weakness was detected when digital content in schools was analysed. There was a difference in some areas between the learners and teachers' preference and what was provided in the digital content in schools. Examples are the formats of the digital content provided and multimedia elements available in the digital content versus teachers and learners preference. The consequence is low utilisation of the curriculum digital content. Editing, piloting, evaluation & vetting and monitoring & evaluation are normally quality checks of the digital content. The steps are critical in any digital content development since they reveal the weaknesses of the content so that they can be addressed. If digital content developers followed all the content development steps, then some of the reasons given by teachers and learners for not utilising Biology digital content would have been addressed.

The study also found out that development of curriculum digital content was a lengthy and resource intensive process. On human resource, it was found out that various specialists are involved in the development process. These included content developers, graphic designers and teachers. It was however noted that researchers, quality assurance officers and KNEC officers were not involved in the process of digital content development. Lack of involvement of some critical officers may lead to development of low quality digital content. Researchers and quality assurance officers for example are critical in needs analysis and ensuring the quality of the digital content developed.

Despite the fact that learners are the main target for the content, they were the least involved basically only during piloting and dissemination of the content. This implies that learners' opinion was not sought either before or during the actual development of the content since piloting and dissemination stages are carried out when the content is complete. Non-involvement of some critical officers and learners in the development process was attributed to massive resources required in the digital content development process. Developers therefore tried to omit some stages and persons required in the development process to minimise the cost of production. This however may not serve as a solution since it leads to development of low quality content that does not put the preference of the user into consideration.

Most of the digital content developers admitted that they faced numerous challenges during curriculum digital content development process. Some of these included the massive resources required to develop digital content, the many stages that must be followed to develop appropriate digital content and the time required to develop quality multimedia elements for the content. In addition, developers indicated it was not easy to come up with content layouts that are appropriate to different categories of learners and the threat of piracy of their content. Some of the solutions suggested to counter these challenges include government subsidies on hardware and software required for curriculum digital content development, government facilitation of some stages of curriculum digital content development and establishment of a central database for multimedia elements that is accessible and can be utilised by all the curriculum digital content developers. In addition, a common standardised curriculum digital content platform needs to be developed and proper copyright, patenting, plagiarism, privacy and data protection legislations, policies and mechanisms put in place.

A review of the available literature established that there are various models that have been derived for instructional design. Some of the models reviewed include the ADDIE design model (CET Florida State University, 1975), Greer model (1192), Dick, Carey and Carey model (2001) and Morrison et al. (2007). In multimedia design, Stoney and McMahon (1998), Alessi and Trollip (2001) and Frey and Sutton (2010) models were reviewed. This review revealed that there was no common model that was being used in both instructional and multimedia design processes. In addition, there was no single model for curriculum digital content design and development that was identified during the review. It was however discovered that most of steps applied in these models were closely related to steps followed in digital content development as identified during the interviews with the digital content designers and developers. It was therefore possible to adapt some framework from these models that could assist in devising a curriculum digital content design and development model.

Some of the findings of this study revealed that curriculum digital content in the schools had design issues related to dissemination modes, multimedia elements and the user interfaces which limited its utilisation and effectiveness. An examination of the digital content development process also revealed some issues such as omission of critical content design and development stages. Some of these issues could be resolved by having a standard curriculum digital content development model that could guide the development process. A closer analysis of the instructional and multimedia design models revealed some common stages in most of them and the digital content development process in Kenya. Some of these steps are setting goals and objectives, needs analysis, designing the materials, developing the materials, testing and evaluation. The five stages provided by the ADDIE design model appeared to conclusively summarise these steps although it lacked a revision stage where the instruction designed would be improved. This study therefore came up with a six-stage framework for the curriculum digital content design and development model. It was named ESO digital content design and development model. ESO is an abbreviation of Expert, Stage and Output which are critical for development of effective curriculum digital content.

5.4 Implications of the findings for practice

This study established that a significant number of teachers and leaners accessed and used curriculum digital content for Biology instruction. Teachers indicated that they utilised Biology digital content in various ways including revision with learners, lesson delivery, preparation for lessons and assessment of learners. Learners used the content for revision, handling assignments and for general knowledge. The study also established that utilisation of the curriculum digital content had a positive influence on the assessment and achievement of learners in Biology. However, utilisation of curriculum digital content had no influence on secondary school Biology syllabus coverage. One of the causes of this scenario is navigation issues such as non-standard primary navigation and lack of secondary navigation tools in some content. This made navigation difficult for the users slowing down the rate of content coverage during the instructional process.

On the other hand, not all teachers and learners utilised Biology digital content in the instructional process. This is despite the fact that all the teachers involved in the study were sampled from ESP-ICT phase 1 secondary schools. This was associated with various design issues that made it difficult for teachers and learners to utilise the curriculum digital content in the instructional process among other reasons given by teachers and learners. A close examination of the Biology digital content revealed that it had design flaws on the multimedia elements and user interface that might have influenced its utilisation and efficacy in the Biology instructional process.

An analysis of Biology digital content revealed that it consisted of various multimedia elements including text, sound, animations, illustrations, video clips, photographs and games. In some cases, the content lacked proper combination of these multimedia elements whereby the elements were presented independently. Effective multimedia for teaching and learning requires carefully combining media in well-reasoned ways that take advantage of each medium's unique characteristics. Rating by teachers and learners revealed that text and sound dominated the Biology digital content despite the fact that the two elements are the least interactive and interesting to digital content users. A number of digital content areas had quality issues. Such included captioning, labelling and colouring of illustrations, pace and harmonization of sound, sharpness of images in video clips and captioning of illustrations. All these design issues affected utilisation of the content and even its influence on the instructional process aspects such as syllabus coverage, assessment and achievement of learners.

On the user interface, most Biology digital content analysed presented sound, graphics and text separately as opposed to the recommended all integrated layout. There was variation of navigational tools from content to content, disparity of the icons used for navigational tools and lack of the navigational tools in some content. This made it difficult for users to navigate through the digital content. All these user interface aspects could therefore have lowered the level of utilisation and influence of the curriculum digital content in the Biology instructional process.

These deficiencies could be addressed by modelling the curriculum digital content design and development process using appropriate models. This study therefore proposed a six-step curriculum digital content and design model. This model would guide design and development of effective curriculum digital content for Biology instruction. The stages include Analyse, Design, Develop, Implement, Evaluate and Revise. The model attempts to match every stage of development with the relevant expert and output to ensure that all the necessary steps and persons are involved in the development process. This model was hence named ESO digital content design and development model. ESO is an abbreviation of Expert, Stage and Output which are critical for development of appropriate curriculum digital content. ESO model has a feedback mechanism and provides avenues for quality checks in every stage while allowing a return to the previous stage of development for rectification of any detected faults in the content.

If ESO model is applied in the design of curriculum digital content, then effective content would be developed. This would in turn increase the rate of content utilisation in the instructional process. In addition, utilisation of effective curriculum digital content would lead to a positive influence on the Biology instructional process aspects such as syllabus coverage, mode of assessment and learners' achievement. It is therefore significant to adopt ESO model in curriculum digital content design and development to ensure effective content is developed which in turn would influence the instructional process positively when utilised.

5.5 Conclusions of the study

Based on the findings of this study various conclusions were made. Specific conclusions based on the study objectives were made which then gave rise to more generalised conclusions.

5.5.1 Specific conclusions

This study found out that not all teachers and learners were able to access and utilise Biology digital content in the instructional process. This was despite the fact that all the study schools were ESP-ICT schools that had been provided with the necessary ICT infrastructure and digital content by MOEST and KIE (now KICD). One of the main reasons for this scenario was the way digital content was packaged and disseminated. While most learners and teachers preferred content packaged in both online and offline modes due to its accessibility, most of the content available in the study schools was computer-based only. This made it difficult for learners and teachers to access the content wherever and whenever they needed it for instruction. Hence, the level of utilisation and effectiveness of the Biology digital content was low. Accordingly, it can be concluded that the form of packaging and the mode of dissemination of curriculum digital content affects its utilisation level and subsequently effectiveness in the instructional process.

Teachers and learners indicated that utilisation of curriculum digital content improved various aspects of Biology assessment. Such aspects include the frequency of learners' assessment, types of test items, feedback duration and interactivity of the assessment. A comparison of the achievement between groups that utilised curriculum digital content and those that did not revealed that the ones that utilised the digital content scored better. Utilisation of curriculum digital content in the instructional process consequently improves the mode of assessment and learners' achievement in Biology. Utilisation of curriculum digital content hence has a positive influence on the Biology instructional process.

It was also observed that curriculum digital consisted of various multimedia elements including text, sound, animations, illustrations, video clips, photographs and games.

However, some Biology content lacked proper combination of multimedia elements whereby in most instances the elements were presented independent of each other. Text and sound dominated most of the content despite the fact that majority of the teachers and learners were more attracted to animations, videos and games which are more interactive. The quality of some of the multimedia elements used in the content was low in a number of areas such as sharpness of images in video clips and captioning of illustrations. This may have contributed to the low level of utilisation and influence of the Biology digital content in the instructional process. It can therefore be concluded that the nature and type of multimedia elements, determines the level of the utilisation and influence of curriculum digital content in the Biology instructional process.

Another conclusion made was that, the formulation of the curriculum digital content user interface determines its utilisation and influence in the Biology instructional process. This study found that most of the Biology digital content had text-sound-graphics layout which is less preferred by users. A layout where text, sound and graphics are harmonized (all integrated layout), is more favoured by most users. It is generally agreed that the integrated layout enables more information to be processed by the human brain since different elements such as visuals and sound are presented together. The variation of navigational tools from content to content, disparity of the icons used for navigational tools and lack of secondary navigational tools in some content made it difficult for users to navigate through the digital content. These aspects of the Biology digital content contributed to lack of its utilisation by a considerable number of teachers and learners in the study schools. They also affected its influence on the Biology instructional process.

It was also inferred that improved process modelling like use of ESO model in curriculum digital content development determines its quality and consequently the level of utilisation and influence in the instructional process. An assessment of the digital content development process revealed some faults in the stages followed as well as the persons involved. It was discovered that some developers omitted crucial stages while ignoring critical officers in the process of digital content development. Some of the stages that were mostly omitted are the needs analysis, editing, piloting and monitoring & evaluation. Persons like learners, researchers and quality assurance officers were ignored during development. This could have contributed to the various weaknesses noted in the Biology digital content in schools which may have led to its low utilisation in the instructional process. A model to guide the design and development of effective curriculum digital content was thus derived through this study.

5.5.2 General conclusion

This study found that utilisation of Biology digital content had a positive influence on the assessment and achievement of the learners in Biology, thus, utilisation of curriculum digital content has a positive influence on the Biology instructional process. Further, multimedia elements and the user interface influences the utilisation of the Biology digital content, then, the design of any curriculum digital content determines its utilisation and influence in the instructional process. It can therefore be generally concluded that utilisation and design of secondary school curriculum digital content has an influence on the Biology instructional process.

5.6 Recommendations of the study

This section gives the recommendations of the study both for implementation and further research based on the findings.

5.6.1 Recommendations for implementation

One of the findings of the study was that some teachers and learners had problems utilising Biology digital content for instruction purpose. This is because most of the content was packaged and disseminated in either computer-based or web-based formats as opposed to both formats concurrently. The findings confirmed that teachers and learners preferred digital content that can be accessed both online and offline since they could access it anytime and anywhere. To improve the level of utilisation of digital content, this study recommends that digital content developers should ensure that they package and disseminate digital content in both online and offline modes. This way, the content would be available anywhere, anytime even where there is no internet connectivity.

Further findings of this study disclosed that both teachers and learners pointed out that utilisation of curriculum digital content improved learners' assessment and achievement in Biology. A comparison of the achievement between groups that utilised curriculum digital content and those that did not revealed that the ones that utilised the digital content had better scores. This implied that utilisation of digital content had a positive influence on the Biology instructional process. It is therefore recommended that all schools, and not only ESP-ICT schools, should be provided with proper infrastructure to enable them access and utilise curriculum digital content in the instructional process. This would enhance assessment modes and learners' achievement in secondary schools resulting to an improved final performance.

This study found out that some teachers and learners were of the view that use of digital content enhances understanding of difficult concepts and could therefore improve the pace of syllabus coverage. However, a comparison of syllabus coverage between a group that utilised digital content and the one that did not, revealed no statistically significant difference in syllabus coverage between the two groups. This implies that utilisation of curriculum digital content had no influence on coverage of Biology syllabus contradicting the opinion of the majority of teachers and learners. This could have resulted from factors like lack of course digital content that could be used to enhance syllabus coverage and the navigation issues of the available digital content. It is therefore recommended that digital content developers ought to develop appropriate course digital content for utilisation in schools' level by level. They should also address the navigational issues of the existing content to ensure that navigational tools are available and standardised. This would improve the level and pace of curriculum digital content utilisation leading to improved syllabus coverage.

The study also found some flaws on the type and nature of multimedia elements used in the Biology digital content. In most instances, multimedia elements were presented independent of each other. Teachers and Learners also felt the content was not very interesting to them since it was dominated by text and sound which are not interactive. They indicated that although videos, animations and games were the most interesting to them, they were not commonly used in the Biology digital content. In addition, there were quality issues in a number of areas such as captioning, labelling and colouring of illustrations, pace and harmonization of sound, sharpness of images in video clips and captioning of illustrations lowering the quality of the digital content. To address these issues, the study recommends that proper needs analysis should be done by curriculum digital content developers before the actual digital content development commences. Involvement of the relevant specialists such as content designers, experienced teachers and multimedia designers would help improve the quality of the digital content in terms utilisation of varied multimedia elements, proper combination of multimedia elements and development of high quality elements.

Another finding of this study was that majority of the teachers and learners indicated that the digital content they had accessed had a text-sound-graphics layout. According to the cognitive theory of multimedia learning, human brain can process more information if different elements such as visuals and sound are presented together and therefore an all integrated layout would be the best. Teachers and learners had difficulty in navigating the digital content. The variation of navigational tools from content to content, disparity of the icons used for navigational tools and lack of the navigational tools in some content made it difficult for users to navigate through the digital content. Most of the respondents indicated that their utilisation of digital content would be affected by the content layout and navigational tools. It is therefore recommended that digital content developers should ensure that an all integrated layout is used when developing curriculum digital content. In addition, navigation tools with standard formats in all curriculum digital content should be provided to ensure that navigation of digital content is easy for the users. As a result, utilisation and effectiveness of curriculum digital content would be improved.

This study discovered that some developers omitted some critical stages necessary for development of quality curriculum digital content. Some of the stages skipped included analysis of teachers and learners needs, piloting of the developed digital content, evaluation and vetting of the content and monitoring and evaluation. It was also noted that some critical persons like researchers, quality assurance officers and learners were not involved in the process of digital content development. Lack of involvement of some critical persons may lead to development of low quality digital content. This study therefore recommends modelling of digital content development process using suitable models like ESO to ensure that appropriate curriculum digital content is developed. The model would guide curriculum digital content developers on the stages and persons that should be involved in the design and development process to come up with effective curriculum digital content.

This study revealed that some digital content developers faced several challenges during curriculum digital content development process. Some of these include the massive resources required to develop digital content, the many stages that must be followed to develop appropriate digital content, the time required to develop quality multimedia elements for the content, difficulty in developing an appropriate layout for different categories of learners and the threat of piracy of their content. It is recommended that the cost of hardware and software required in curriculum digital content development be subsidised by the government to lower the cost of digital content production. In addition, curriculum digital content developers should come together and establish a central database for multimedia elements and a standardised curriculum digital content platform that is accessible and can be utilised by all the curriculum digital content developers. Moreover, the government should put in place proper copyright, patenting, plagiarism, privacy and data protection legislations, policies and mechanisms to protect the digital content developed by different developers.

5.6.2 Recommendations for further research

This study found out that there were some design issues in Biology digital content that limited its utilisation and effectiveness in the instructional process. Such issues were detected in its dissemination mode, multimedia elements and the user interfaces. It is important to study curriculum digital content in other subjects and find out whether such defects exist.

The study also found out that the utilisation of curriculum digital content had a positive influence on the assessment and learners' achievement in Biology tests. It is would be interesting to establish whether utilisation of curriculum digital content has such influences in other subjects.

Despite teachers and learners' opinion that utilisation of curriculum digital content may improve the pace of syllabus coverage, the study revealed no significant difference in syllabus coverage between the group which utilised Biology digital content and the one that never used the content for instruction. A study in another subject or location to establish whether there was any relationship between utilisation of curriculum digital content and coverage of the syllabus would be important.

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APPENDICES

APPENDIX I

BIOLOGY TEACHER QUESTIONNAIRE

This questionnaire is designed to collect data for my PhD study research. I would wish to request for your cooperation and assure you that all the information given shall remain confidential and will only be used for the purpose of this study.

The questionnaire consists of two parts: -

Part A: personal information

Part B: Instructional information

PART A: PERSONAL DATA

School name………………………………………………………………..................

Class…………………Teacher's teaching experience….……………………………….

Academic qualification………………………………………Date………………….

ICT skills: None…………. Basic….…………. Advanced……………………………

PART B: INSTRUCTIONAL INFORMATION

1. Do you access and utilize digital content for Biology instruction?

Item	Yes	No
Access Biology digital content		
Utilize Biology digital content for instruction		

If your answer is No, please give reasons.
………………………………………………………………………………………
………………………………………………………………………………………
……

2. In which format, do you access Biology digital content?
    a. Web-based format
    b. Computer-based format

3. Which format would you prefer to access digital content for teaching Biology?
    a. Web-based format
    b. Computer-based format

4. Which ICT devices do you use to access Biology digital content?
    a. Computers
    b. Mobile devices
    c. Tablets
    d. Digital televisions
    e. Top set boxes
    f. Others (specify)

5. Which devices are used for storage of digital content that you use in teaching Biology?
    a. Local hard disks
    b. External hard disks
    c. DVDs
    d. CDs
    e. Flash disks
    f. Memory cards
    g. Cyber space
    h. Others (specify)

6. How do you use Biology digital content?
    a. Preparing lessons
    b. Preparing tests
    c. Content delivery
    d. Others (specify)

7. Which navigational tool(s) are provided in the Biology digital content?

Navigational tools	Availability		Form of presentation		
	Yes	No	Text	Icon	Text & Icon
Play					
Pause					
Stop					
Next					
Previous					
Exit					

8. Which other support module(s) are provided in Biology content?

Support tool	Availability		Form of presentation		
	Yes	No	Text	Icon	Text & Icon
Search					
Help					
Glossary					

9. What is your preferred form of the presentation of the navigational and support tools?
    i) Text form
    ii) Icon form
    iii) Combination of text and icon
10. Do the provided navigational tools and supporting modules influence the way you utilize Biology digital content?
    a. Yes
    b. No

    Explain your answer
    …………………………………………………………………………………………
    …………………………………………………………………………………………
    ……
11. Rate the multimedia elements in terms of their presence and interest in Biology digital using the provided scale.

    Rating scale
    a) Presence: 1- not common, 2- fairly common, 3- common, 4- most common
    b) Interest: 1- not interesting, 2- fairly interesting, 3- interesting, 4-very interesting

Multimedia component	Presence of the component				Interest of the teacher			
	1	2	3	4	1	2	3	4
Electronic text								
Sound								
Animations								
Illustrations								
Videos								
Photographs								
Puppets								
Games								

12. To what extent do you agree with the following statements about the multimedia elements in Biology digital content?
    (Use the key: SA=’Strongly agree’, A=’Agree’, NS=’Not sure’, D=’Disagree’ and SD=’Strongly disagree’)
    For each item, provide a brief comment to elaborate on your response, **if necessary**.
    (Tick the appropriate box)

	SA	A	NS	D	SD
i) The photos are clear; (have sharp images, correct proportion and colour and are properly captioned)					
Comment:					

ii) The photos are relevant to the topical areas					
Comment:					
iii) The sound is clear; (audible, no background interference, is well paced and relevant to the topical areas)					
Comment:					
iv) The sound is properly harmonized with the text throughout the content					
Comment:					
v) The videos are clear; (sharp images, good pace and logical flow)					
Comment:					
vi) The videos are relevant to the topical areas.					
Comment:					
vii) All the videos are properly harmonized with the sound.					
Comment:					
viii) The illustrations are clear;(sharp image, correct colour, correct proportion, labelled and captioned)					
Comment:					
ix) The animations are properly harmonized with the sound throughout the content.					
Comment:					
x) The multimedia elements are well positioned in reference to the text in the content.					
Comment:					
xi) The learner is well directed on how to navigate through the content (use of next, up, down, back, forward and play)					

Comment:					
xii) Puppets are well harmonized with the sound throughout the content					
Comment:					

13. Do you think the multimedia elements provided in the digital content influence the utilisation of the content in Biology instruction?
    a. Yes
    b. No

    If your answer is Yes, please explain how
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
14. How is the Biology content organized in terms of graphics in relation to sound and text?

Content	Arrangement of elements						
	Graphics-Sound-Text	Graphics Text-Sound	Sound-Graphics-Text	Sound-Text-Graphics	Text-Graphics Sound-	Text-Sound-Graphics	All integrated
A							
B							
C							
D							
E							

15. Do you think the organization of the content has any influence on the utilisation of Biology digital content?
    a. Yes
    b. No

Explain your answer
……………………………………………………………………………………………
16. Do you think that use of digital content helps you to cover Biology syllabus faster?
    a. Yes
    b. No
17. In your opinion, is there any relationship between syllabus coverage and learners achievement in Biology?
    a. Yes
    b. No
18. Does the use of digital content have any effect on your assessment in Biology?
    a. Yes
    b. No

19. To what extent do you agree with the following statements about the learners' assessment when Biology digital content is utilised?
Use the key: SA='Strongly agree', A='Agree', NS='Not sure', D='Disagree' and SD='Strongly disagree' (Tick the appropriate box)

Assessment factors	SA	A	NS	D	SD
Learners assessment is more frequent with Biology digital content					
Learners can be assessed using a variety of test items					
Learners are given feedback immediately					
Assessment of learners is adequate					
Assessment methods are more interactive					

Please give your comments on these factors
....
....
....
....
....

20. Do you think there is any relationship between use of digital content in Biology instruction and learners' achievement in your opinion?
    a. Yes
    b. No

    Please explain your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
    ……………………………………………………………………………………

APPENDIX II

LEARNERS FOCUS GROUP DISCUSSION GUIDE

SCHOOL……………….………………………………….CLASS………….…………

ICT SKILLS: None…...…Basic…..…Advanced……..DATE……………………..…

1. Do you access and use digital content to learn Biology?
    a. Yes
    b. No

    If your answer is No, please give reasons
    ………………………………………………………………………………………
    ………………………………………………………………………………………
2. In which format, do you access Biology digital content?
    a. Web based
    b. Computer based
3. Which format would you prefer to access digital content for learning Biology?
    a. Web based
    b. Computer based
4. Which ICT devices do you use to access Biology digital content?
    a. Computers
    b. Mobile devices
    c. Tablets
    d. Digital televisions
    e. Top set boxes
    f. Others (specify)
5. Which devices are used for storage of digital content that you use for learning Biology?
    a. Local hard disks
    b. External hard disks
    c. DVDs
    d. CDs
    e. Flash disks
    f. Memory cards
    g. Cyber space
    h. Others (specify)
6. How do you use Biology digital content?
    a. Personal studies
    b. Revision
    c. Handling class assignments
    d. Others (specify)
7. Rate the following multimedia elements in terms of their presence and interest in Biology digital using the provided scale.

Rating scale

Presence: 1- not common, 2- fairly common, 3- common, 4- most common
Interest: 1- not interesting, 2- fairly interesting, 3- interesting, 4-very interesting

Multimedia component	Presence of the component				Interest of the learner			
	1	2	3	4	1	2	3	4
Electronic text								
Sound								
Animations								
Illustrations								
Videos								
Photographs								
Puppets								
Games								

8. Do you think the multimedia elements provided in the digital content influence your use of digital content in learning Biology?
   a. Yes
   b. No

If your answer is yes, please explain how?
……………………………………………………………………………………………
…………………………………………………………………………………………….

9. Which navigational tool(s) are provided in the Biology digital content?

Navigational tools	Availability		Form of presentation		
	Yes	No	Text	Icon	Text & Icon
Play					
Pause					
Stop					
Next					
Previous					
Exit					

10. Which support tool(s) are provided in Biology content?

Support tool	Availability		Form of presentation		
	Yes	No	Text	Icon	Text & Icon
Search					
Help					
Glossary					

11. What is your preferred form of the presentation of the navigational and support tools?
    i) Text form
    ii) Icon form
    iii) Combination of text and icon
12. Do the provided navigational tools and supporting features influence the way you utilize Biology digital content?
    a. Yes
    b. No

    Explain your answer

    ………………………………………………………………………………………
    ………………………………………………………………………………………
13. How is the Biology content you have accessed organized in terms of graphics in relation to sound and text?

Content	Arrangement of elements						
	Graphics-Sound-Text	Graphics Text-Sound	Sound-Graphics-Text	Sound-Text-Graphics	Text-Graphics Sound-	Text-Sound-Graphics	All integrated
A							
B							
C							

14. Do you think the organization of the content has any influence on your use of digital content in learning Biology?
    a. Yes
    b. No

Explain your answer

………………………………………………………………………………………
………………………………………………………………………………………

15. Do you think that use of digital content helps you to cover Biology syllabus faster?
    a. Yes
    b. No
16. To what extent do you agree with the following statements about the learners' assessment when Biology digital content is utilised? Use the key: SA='Strongly agree', A='Agree', NS='Not sure', D='Disagree' and SD='Strongly disagree'

	Assessment factors	SA	A	NS	D	SD
1	I am able to assess myself during personal studies					
2	I receive immediate feedback after assessment					
3	The assessment provided in the digital content is interesting					
4	Enough assessment items are provided					
5	I am in control of my own assessment					

17. Are the methods used in assessment tests that you do in Biology varied?
    a. Yes
    b. No

    Please explain your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
    ……
18. Do you think the assessment tests that you are given in Biology are adequate?
    a. Yes
    b. No

    If you answer is no, please explain
    ……………………………………………………………………………………
    ……………………………………………………………………………………

19. Is the feedback for Biology assessment tests given promptly?
    a. Yes
    b. No

    Please explain your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
20. Do you think that the assessment tests you do in Biology have any influence on your main achievement such end of term tests?
    a. Yes
    b. No

    Please explain your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
21. Do you think use of digital content has influenced your achievement in Biology?
    a. Yes
    b. No

    Please explain your answer
    ……………………………………………………………………………………
    ……………………………………………………………………………………
    ……………………………………………………………………………………

APPENDIX III

BIOLOGY TEACHING AND LEARNING RESOURCES INVENTORY

SCHOOL………………………………………DATE………………………

1. Digital content access devices in the school

Device	Availability
Computers	
Cell phones	
Tablets	
Set top box	
Digital televisions	

2. School connectivity

Type	Availability
Internet	
Intranet	
Extranet	

3. Digital content availability and use

Type	Availability
Course content	
General reference content	
Revision content	

4. Content storage devices availability and use

Device	Availability
External hard disks	
Memory cards	
Flash disks	
DVDs	
CDs	
Dongles	

5. Other Biology teaching and learning resources

Resource	Availability
Reference materials such as syllabus and text books	
Equipped science laboratory	
ICT integration laboratory	

APPENDIX IV

DIGITAL CONTENT ANALYSIS SHEET

SCHOOL: ………………………………………………. DATE………………………

1. Multimedia elements available in the Biology digital content

Digital content	Multimedia elements in the content						
	Text	Sound	Animations	Illustrations	Videos	Photographs	Games
a							
b							
c							

2. Arrangement of graphics in relation to sound and text in the Biology digital content

Digital content	Arrangement of elements						
	Graphics-Sound-Text	Graphics Text-Sound	Sound-Graphics-Text	Sound-Text-Graphics	Text-Graphics Sound-	Text-Sound-Graphics	All integrated
a							
b							
c							

3. Navigational tools available in the Biology digital content

S/No.	Tool	Availability		Presentation		
		Yes	No	Graphical	Text	Both
a	Play					
	Pause					
	Stop					
	Next					
	Previous					
	Exit					
	Others (specify)					
b	Play					
	Pause					
	Stop					
	Next					

	Previous					
	Exit					
	Others (specify)					
c	Play					
	Pause					
	Stop					
	Next					
	Previous					
	Exit					
	Others (specify)					

3**.** Availability and form of support tools in the Biology digital content

S/No.	Tool	Availability		Presentation		
		Yes	No	Graphical	Text	Both
a	Search					
	Help					
	Glossary					
	Others (specify)					
b	Search					
	Help					
	Glossary					
	Others (specify)					
c	Search					
	Help					
	Glossary					
	Others (specify)					

APPENDIX V

DOCUMENTS ANALYSIS SHEET

School name ……………………………………………………………

Use digital content: Yes………………………. No……………………….

1. Records of work analysis

Class	Covered topics	Uncovered topics	Total number of syllabus topics	Percentage coverage
Form 1				
Form 2				
Form 3				
Total				

2. Learners notes

Class	Covered topics	Uncovered topics	Total number of syllabus topics	Percentage coverage
Form 1				
Form 2				
Form 3				
Total				

3. Progress records

Assessment test	Mean test score	Maximum score	Percentage
Form 1, Term III			
Form 2, Term I			
Form 2, Term II			
Form 2, Term III			
Form 3, Term I			
Form 3, Term II			
Total			

APPENDIX VI

DIGITAL CONTENT DEVELOPERS INTERVIEW SCHEDULE

1. Do you develop Biology digital content in your institution?

   YES NO

2. a) Which stages do you follow in the development of the Biology digital content among the ones listed on the table?

Steps of content development		**Involvement**	
		Yes	**No**
1	Needs analysis		
2	Content selection		
3	Scripts development		
4	Editing of the scripts		
5	Multimedia elements development		
6	Text formatting		
7	Elements integration (content authoring)		
8	Editing of the content		
9	Review of edited content		
10	Piloting of the content		
11	Review of piloted content		
12	Evaluation and vetting of the content		
13	Review of vetted content		
14	Content dissemination		
15	Monitoring and evaluation		

b) List any other stage(s) that are involved in the development of digital content in your institution that are not indicated on the table.
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

3. a) To what extent in percentage are the following persons involved in the process of development of your Biology digital content?

	Involved persons	Percentage involvement	Percentage level of involvement
1	Researchers		
2	Teachers		
3	Learners		
4	Education officers		
5	Quality assurance officers		
6	KNEC officers		
7	Software engineers		
8	Script developers		
9	Content developers		
10	Sound artists		
11	Sound technicians		
12	Game designers		
13	Video technicians		
14	Photograph technicians		
15	Animators		
16	Illustrators		

b) List any other person(s) involved in the development of your Biology digital content.
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………

4. In which format, do you package your Biology digital content?
    a. Web-based
    b. Computer-based
    c. Both web-based and computer-based

5. How do you disseminate your Biology digital content?
    a. Online
    b. Offline
    c. Both online and offline

6. Which challenges do you encounter in the process of the development of Biology digital content?
……………………………………………………………………………………………
……………………………………………………………………………………………

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

7. In your own assessment, how can the process of digital content development be improved to ensure development of quality content?

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

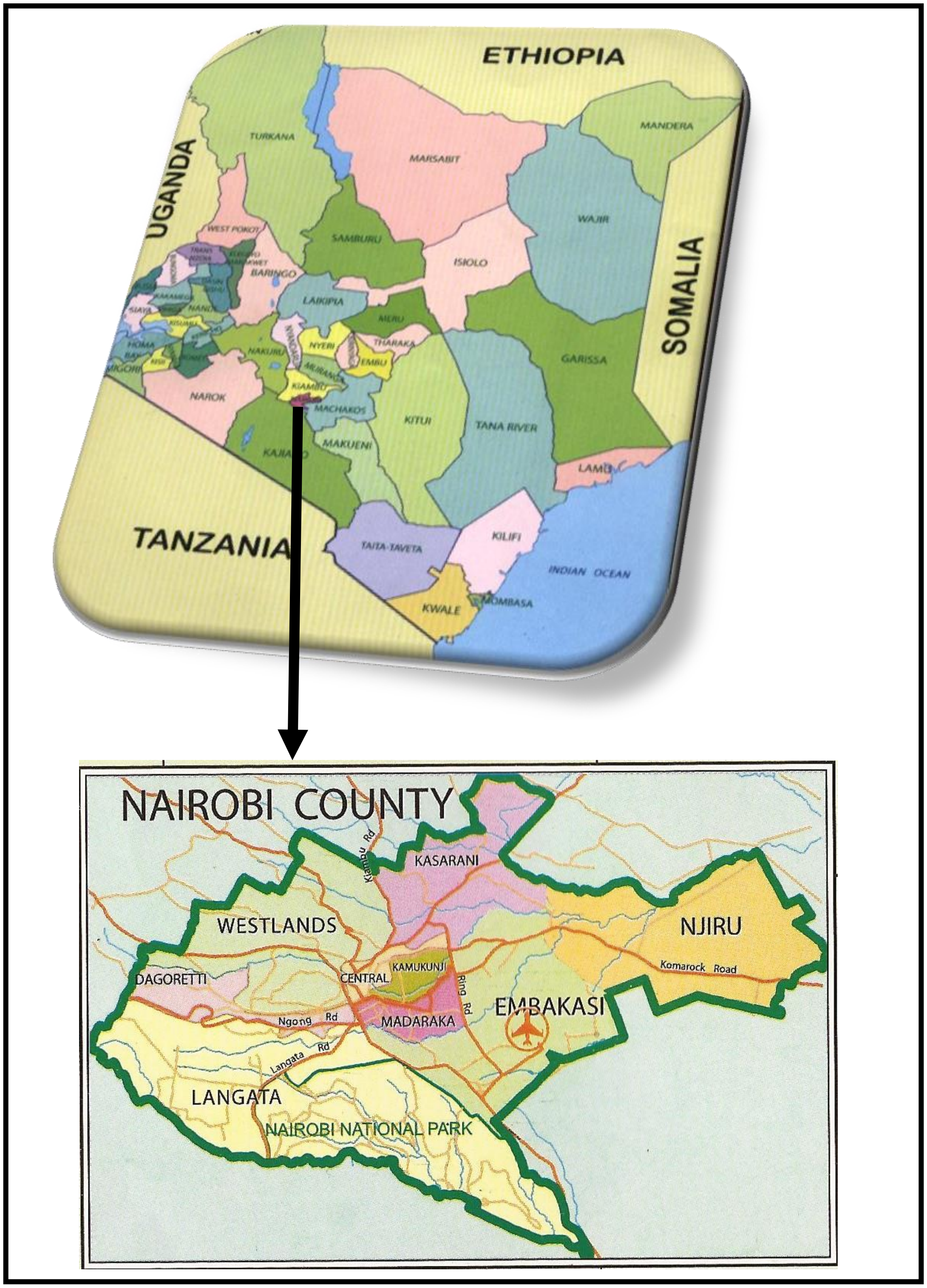
APPENDIX VII

LIST OF ESP-ICT PHASE 1 SCHOOLS IN NAIROBI COUNTY (2010-2011)

S/NO	SCHOOL	CONSTITUENCY IN 2011
1	Mutuini High School	Dagoretti
2	Dagoretti Mixed Secondary School	Dagoretti
3	Ruthimitu Mixed Secondary School	Dagoretti
4	Ruthimitu Girls Secondary School	Dagoretti
5	Dagoretti High School	Dagoretti
6	Mwangaza Secondary School	Embakasi
7	Kayole South Secondary School	Embakasi
8	Dandora Secondary	Embakasi
9	Ruai Girls Secondary	Embakasi
10	Jehova Jire Secondary	Embakasi
11	Maina Wanjigi Secondary School	Kamukunji
12	Uhuru Secondary School	Kamukunji
13	Eastleigh Secondary School	Kamukunji
14	Kamukunji Secondary School	Kamukunji
15	Baba Ndogo Secondary School	Kasarani
16	Kahawa Garrison Secondary School	Kasarani
17	Our Lady of Fatima	Kasarani
18	Kamiti Secondary School	Kasarani
19	Kariobangi North Girls Secondary School	Kasarani
20	Langata Secondary School	Langata
21	Olympic Secondary School	Langata
22	Langata Barracks Secondary School	Langata
23	Raila Education Centre	Langata
24	Karen C Secondary School	Langata
25	Muranga Road Secondary School	Starehe
26	C.G.H.U. Mixed Day Secondary	Starehe
27	St. Teresas Girls Day Sec.	Starehe
28	Pumwani Boys Secondary	Starehe
29	Ndururuno Mixed Secondary	Starehe
30	Hospital Hill High School	Westlands
31	State House Girls	Westlands
32	Kangemi High School	Westlands
33	Arya girls High School	Westlands
34	St. Georgies Girls School	Westlands
35	Our Lady of Mercy South B Secondary School	Makandara

APPENDIX VIII

LOCATION OF NAIROBI COUNTY IN KENYA



APPENDIX IX

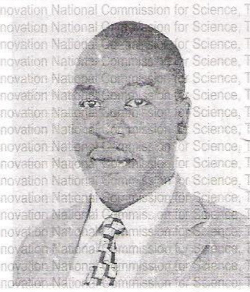
RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. SAMUEL NYAGA JESSE
of KENYATTA UNIVERSITY, 30231-100 Nairobi,has been permitted to conduct research in *Nairobi County*

on the topic: *IMPACT OF CURRICULUM DIGITAL CONTENT ON BIOLOGY INSTRUCTIONAL PROCESS AMONG SECONDARY SCHOOLS IN NAIROBI COUNTY, KENYA*

for the period ending:
31st December,2015

Permit No : NACOSTI/P/14/5772/3380
Date Of Issue : 30th September,2014
Fee Recieved :Ksh 2,000



....
Applicant's Signature

....
Secretary
National Commission for Science, Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 3411

CONDITIONS: see back page

APPENDIX X

RESEARCH AUTHORIZATION

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No.

Date:
30th September, 2014

NACOSTI/P/14/5772/3380

Samuel Nyaga Jesse
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Impact of curriculum digital content on biology instructional process among secondary schools in Nairobi County, Kenya,''*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for a period **31st December, 2015.**

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

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

COUNTY DIRECTOR OF EDUCATION NAIROBI
07 OCT 2014
MINISTRY OF EDUCATION
P. O. Box 74629, NAIROBI.

DR. M. K. RUGUTT, PhD, HSC.
Ag. SECRETARY/CEO

Copy to:

COUNTY COMMISSIONER
NAIROBI COUNTY
P. O. Box 30124-00100, NBI
TEL: 341666

The County Commissioner
The County Director of Education
Nairobi County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified