EFFECT OF ANIMATIONS IN E-LEARNING MATERIALS ON STUDENTS’ PERFORMANCE IN PHYSICS AMONG SELECTED SECONDARY SCHOOLS IN NAIROBI CITY COUNTY, KENYA.

BY:

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REG. NO: E83/23586/2012

A THESIS SUBMITTED FOR AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE SCHOOL OF EDUCATION, KENYATTA UNIVERSITY.

SEPTEMBER, 2020
DECLARATION
I declare that this thesis is my original work and has not been presented in any other University / Institution for consideration. The thesis has been complemented by referenced sources duly acknowledged in line with anti-plagiarism regulations.

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DEDICATION
This thesis is dedicated to my loving wife Susan Nkatha and children Joshua Mwendwa and Elijah Mumo for their endless support and understanding while I was away both physically and mentally compiling this work. They endured and tolerated my long-term absence over this period.
ACKNOWLEDGEMENT

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<td>AI</td>
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<td>CEMASTEA</td>
<td>Centre for Mathematics, Science and Technology Education in Africa</td>
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<td>CG</td>
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<td>CMI</td>
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<td>DCT</td>
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<td>EMIS</td>
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<td>ESP</td>
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<td>IBT</td>
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<td>ICT</td>
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<td>IDC</td>
<td>Interactive Digital Content</td>
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<td>IMM</td>
<td>Interactive Multi - Media</td>
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<td>KEMI</td>
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KIE - Kenya Institute of Education
KNEC - Kenya National Examinations Council
LCD - Liquid Crystal Display
LCMS - Learning Content Management System
LMS - Learning Management System
MEST - Ministry of Education, Science and Technology
MKE - Ministry of Knowledge Economy
MoE - Ministry of Education
MoEST - Ministry of Education, Science and Technology
MR - Mixed Reality
NACOSTI - National Commission for Science, Technology and Innovation
NEMIS - National Education Management Information System
PASW - Predictive Analytics Software
SPMC - Stimulus Project Management Committee
SPSS - Statistical Package for Social Sciences
TEL - Technology Enhanced Learning
TPACK - Technological, Pedagogical and Content Knowledge
TSC - Teachers Service Commission
VLE - Virtual Learning Environments
VR - Virtual Reality
WBT - Web Based Training
ABSTRACT
This study focused on the effect of the animations embedded in e-learning materials produced at the Kenya Institute of Curriculum Development. The first objective of this study was to determine the influence of instructional values inculcated by animations embedded in Interactive Digital Content (IDC) on performance of learners in Physics. The second objective was to determine the effect of animations on the concentration span of learners while learning Physics and the last one was to develop a process model for development of quality animations in Physics education. The third one sought to find out if animations enhance conceptual understanding of text within the interactive Physics digital content. Lastly, this study sought to develop an instructional model. It was guided by the Paivio’s dual – coding theory of learning and was done in Nairobi County. Four public secondary schools were purposively sampled out of sixty public secondary schools in the County. One hundred and four students from the sampled schools were involved in the study. Quasi – experimental research design was used. The instruments used in collecting data were piloted in two schools. After piloting, the instruments were validated and made more reliable. During the study, a pre-test was administered to the learners selected to participate in the control and experimental groups and their performance was determined and their scores were recorded. Treatment was given to the two schools in the experimental group where they were given IDC with animations. The control schools were given content without animations. Both groups were given a post – test after interacting with the provided IDC to determine their performance on the topics tested during pre-test. Data was analysed using descriptive statistics and inferential statistics. The scores were recorded for both groups and the data collected was analysed to determine whether there was a significant difference in the performance of the learners in the two study groups. The findings from the study showed that performance of the learners who used the IDC with animations improved significantly. After comparing the means of the learners in the two study groups, during pre-test, the mean posted by learners in the control group was 11.35 while learners in the experimental group posted a mean of 15.40. The difference between the means of the two groups in pre-test was calculated using T-test which gave \( t (90.48) = -1.60, p = 0.64 \). This shows that the difference between their means was not significant and therefore the groups dealt with were of equivalent ability. During post-test, learners in the control group posted a mean of 12.88 while their counterparts in the experimental group had a mean of 25.27. The significance of the difference between the two means was calculated using T-test which gave \( t (102) = -3.45, p = 0.001 \). This shows that there was a significant difference between the means posted by the subjects in the two study groups during the post-test. The results from the data collected from the teachers’ questionnaire, learners’ questionnaire and the observation schedule show that learner’s conceptual understanding of Physics content was enhanced when they used animations and similarly, use of IDC provided stimulus variation more hence extending the learners’ concentration span. It is therefore recommended that the Ministry of Education should review the policy on instructional materials to include Physics IDC with animations and emphasize that Physics educators should use such content.
CHAPTER ONE
INTRODUCTION

1.0 Introduction

This chapter comprises of background to the study. It also has statement of the problem, purpose of the study, objectives of the study, hypotheses of the study, significance of the study, scope and limitations of the study, basic assumptions of the study, theoretical framework, conceptual framework and definition of key terms used in the study.

1.1 Background to the Study

The rapid and dynamic development in technology in the recent past has provided opportunities for learners to use various technology tools in the education process globally. Sangra, et al. (2012) state that e-learning represents a broad combination of processes, content and infrastructure to use computers and networks to improve necessary parts of the learning value chain. Garrison (2002) notes that e-learning contributes to the increase of the quality of learning experiences. One component of e-learning which can increase the quality of learning is use of multi-media elements embedded in it. These multimedia elements include animations, videos, illustrations, photographs, audio and text. Computer animation entails bringing inanimate objects to life on a screen. Animation is classified into two – dimensional or three - dimensional orientations and they are geared towards improving the learners’ achievement level. Achievement level in this context refers to the cumulative performance of a learner, displayed in competencies to demonstrate a specific skill or knowledge actualization. (Achuonye, 2011).
In the Republic of Macedonia, many projects related to the digitalization of education system have been implemented since 2002 (Gudachi, 2018). The process digitizing the education system began with development and adoption of the legal provisions. They developed a strategy for e-content development from the year 2010 and finished this process in the year 2015. This legal framework and related national documents are envisaged to establish clear foundation and path towards digital education in the entire country. The country has undertaken many projects such as “Computer for every child” where 180,000 computers were provided learners. In this project, all schools in the country received ICT equipment, software and interactive on-line teaching materials. The government has also put in place measures to ensure that the ICT equipment is in good condition through efficient maintenance of computer equipment and computer networks. Jovevski, et al. (2016) state that the use of ICT in Macedonian schools is no longer a choice and represents a need for communicating, researching and changing the habits. In addition to this, almost all textbooks except those without copyrights were converted into the digital format and put in an online portal where all relevant parties can access them for learning purposes (Metamorphosis, 2011). Since 2007, the Bureau for Development of Education (BDE) in the country has mapped digital content into the curriculum by subject and level departments. This resulted in digitization of content in 513 subjects by the end of 2009. Most of the digitized subjects were related to Science and they have multimedia elements such as animations, videos, audio, text and images embedded in them. It is worth noting that this number is not considered sufficient and there is a need to augment the number and the quality of such contents (BDE, 2012).

One of the countries whose education system has greatly led to economic growth is South Korea. This country has experienced enormous economic growth over the last fifty years and
now is one of the largest economies in the world. During the period between 1960 and 2012, its gross domestic product per capita increased from $1,467 to $21,562 (World Bank 2014). The economic and societal development of South Korea has been a success story since the 1960s. Much of this development has been attributed to improvements in the country’s education system (Bermeo, 2014).

The Republic of Korea has developed a robust Information Technology (IT) infrastructure and Internet facilities countrywide. Currently, the average number of learners per personal computer is 5.8 and 70.7% of schools are equipped with 2 mega bites per second Internet lines. Majority of the population in Korean Republic is able to access the Internet. Internet utilization rate is at 64.1% and 89.9% of the population use the Internet at home (KERIS, 2008).

Korean Republic adopted e-learning in 80.0% of its regular education institutes in 2009 (Hwang, Yang and Kim, 2010). Introduction of Information and Communication Technologies (ICT) in education began with computer literacy education and was further extended to nurture human capital by allowing more opportunities for learning and improving the quality of education. Policies for ICT and e-learning were initiated by the Ministry of Education Science & Technology (MEST) in association with the projects driven by Ministry of Knowledge Economy (MKE) in 1987. Some examples are the National Basic Information System Project, High Speed Broadband Network Project, Framework Plan for IT Development, and the e-Government Project. MEST coordinates the process of ICT policy making, establishing ICT infrastructure, teacher training, evaluation and monitoring. MKE has been undertaking initiatives to establish communication networks infrastructure including Local Area Network connections at each school and nationwide high-speed Internet for elementary and secondary schools. In this regard
ICT policy in education has been implemented through collaboration between MEST and MKE (MKE, 2006).

The implementation of ICT policy in education was done in three stages in terms of the establishment and expansion of its usability. The first phase was aimed at establishing a robust ICT infrastructure to initiate the educational information service. The second phase was focused on quality education and open access to the information related to the education and training services available within the ICT infrastructure: e-learning and capacity building programme for teachers and heads of elementary and secondary schools. The third phase was technically designed to create sustainable learning environments including mobile learning which provides learners with more flexibility and more secure education information service. This was developed further to allow learners in primary and secondary schools to use digital textbooks instead of printed textbooks.

With the accelerated increase in the use of e-learning, its quality management required the attention of all educational stakeholders. In addition, increased attention was paid to the sustenance of high quality e-learning services running at schools, cyber universities, as well as e-learning institutions established for job training, teacher training and government official training. According to the results of the national poll, Korean learners found that the most attractive features of e-learning were cost saving and learning time followed by system stability, content quality, diversity and learning effects. The quality of the content used by Korean learners is enhanced through the use of animations, images, audio and text.

South Korea has been developing animations for educational purposes and embedding them in educational content. According to Yoon (2010), since the 1990s, the Korean animation industry
has tried to become an autonomous agent by producing its own animations. The animation industry in Korea is the third largest globally after USA and Japan. Nowadays, Korea does not rely on the United States of America or Japan to have their animations designed and developed as it was the case some years back. The Korean animation industry is now striving to be self-sufficient by generating creative agents among the Korean citizenry. The central goal of the Korean animation industry and of the Korean government is to encourage Korean animators to be more creative in order to produce more creative Korean animations. The creativity of the Korean animators is enhanced by providing education related to creativity, offering a variety of events to familiarise audiences and consumers with animation and obtain sponsors for young animators.

Most recently, Korea became the first country in the world to replace print textbooks with electronic versions. Bermeo (2014) indicates that these digital versions include the content of existing textbooks which incorporates digital media resources such as video clips, animation and virtual reality. The Digital Textbook Promoting Plan was created to make high-quality digital textbooks suitable for the educational environment of the future and to support the goal of “Knowledge Korea” by developing the national database for teaching–learning and by exporting such information throughout the world (Severin and Capota 2011).

In Africa, there are more learners in primary school than ever before; more girls going to school and more women who are literate (Isaacs and Hollow, 2012). In Nigeria, there are very few known schools that have adopted high level digital education. Aiyebelinhin (2012) studied the influence of teachers’ information needs on ICT use in schools in Oyo state, Nigeria and found that, computer, multimedia boards, projectors, telephones, internet, scanners and photocopiers
were used by teachers. Further from his findings the largest percentage of computer users (57.26%) reported to be monthly users, the largest percentage of multimedia users (52.56%) reported to be occasional users, and the largest percentage of projector users 125 (53.42%) reported to be occasional users.

Ajadi, Salawu and Adeoye (2008) observed that the most common type of e-learning adopted in Nigerian schools was in the form of lecture notes on CD-ROM which can be played whenever the learners desire. However, other studies done later in Nigeria show that there is an increased use of ICT integration in learning. Yisa and Ojiaku (2016) point out that researchers in Nigeria have carried out studies to find out ways of integrating ICT in the classroom as supplements for conventional method of teaching in order to enhance the performance of learners in different subjects. Some of these alternative methods of teaching the Science subjects include use of simulated experiments and Computer Animation Instructional Package (CAIP).

Gambari, Falode and Adegbenro (2014) examined the effect of computer animation and geometry instructional model on Mathematics achievement and retention of Junior Secondary School Students in Minna, Nigeria. The results indicated that the learners taught geometry using computer animation performed significantly better in post-test and retention test than their counterparts taught geometry using instructional model and conventional method respectively. These findings indicated that geometry concept in mathematics could be taught and learnt meaningfully through the use of computer animation. Falode, Sobowale, Saliu, Usman, and Falode (2016) determined the effect of CAIP on academic achievement of senior secondary school agricultural Science learners in animal physiology in Minna, Nigeria. Findings revealed
that there was significant difference between the mean achievement scores of the two groups in favour of those taught with CAIP.

The government of Kenya has done a lot pertaining to digitization in education and training in general. The Government of Kenya developed an ICT strategy in education in the year 2006 which emphasized on ensuring equity, increasing access and improving quality of education offered to learners at all levels of education and training. After the formulation of this strategy, Kenya Institute of Curriculum Development (KICD), the then Kenya Institute of Education (KIE), was given the responsibility of producing interactive digital content since this type of content was seen as one way of meeting the requirements of this strategy. Interactive digital content in the broad sense refers to any information that is published or distributed in a digital form, including text, data, sound recordings, photographs and images, motion pictures and software that are available for downloads or distribution on electronic media. KICD began to produce e-learning materials (digital content) for use with computers back in the year 2006. It began with development of Form One content. These subjects included Mathematics, Physics, Chemistry, Biology, English, Kiswahili, History, Agriculture, Home Science, Geography, Computer studies and Business studies. KICD continued to produce digital content for the secondary school level since then and in the year 2014, content has been produced from Form One to Form Four in the twelve subjects as listed earlier.

In the 2009/2010 Financial Year (FY), the concept “Economic Stimulus Programme (ESP)” came into existence during the Budget speech read to the Kenyan parliament in this financial
year. The ESP identified numerous projects per constituency which were to be funded with over Kshs.100 million in every constituency. By then, the total number of constituencies in Kenya was two hundred and ten (210). The aim of the programme was to support local development projects by creating employment and providing essential services like education.

The ESP was to be coordinated by the Ministry of Finance at the national level. However, the Education sector programme was to be implemented through the Ministry of Education (MoE). In this sector, focus was on improving the quality of education and one way of doing this was through purchasing Form One interactive digital content in twelve subjects for at most five schools in every constituency (KICD research report series No. 113, 2013). In addition to the interactive digital content, the ESP schools were also given an LCD projector, one laptop, internet connectivity for one year, a printer and eleven desktop computers under this programme. Due to the enormous number of schools in the country, the ESP programme was implemented in three phases to enable the beneficiaries do adequate logistical planning and facilitate distribution of the equipment and to ensure adequate security of the ICT devices and tools.

In the year 2011, one thousand and twenty one (1,021) schools benefited under phase one of this programme and they collected the content from KICD. In the subsequent years, other schools have also been able to benefit under phase two and three of the same programme. In phase two, three hundred and seventy eight (378) schools were given packages similar to what was given to schools under phase one. Under phase three, two hundred and ten (210) schools benefited and collected the content from KICD. The beneficiaries of phase three were supposed to be given content for Form Two in twelve subjects in addition to what schools in phase one and two got.
Some schools have gone an extra mile and managed to purchase digital content either from KICD or commercial content developers on their own. This implies that some of our schools have digital content either from KICD or other sources. A Frankfurt book fair study surveying one thousand (1000) publishing professionals from over 30 countries showed that 40 percent of the respondents believe digital content will overtake traditional books in future sales (Eaton, 2009). Aronson (2007) wonders whether non-fictional books will be replaced by the digital resources and further indicates that new technologies will not always replace the old but they will rather co-exist. This discussion is summed up by stating that we are entering an era where media will be everywhere, and we will use all kinds of media in relation to one another. In other words, Aronson sees books as radio programs that are flourishing in the age of television, interactive digital content with animations among other educational resources. In Kenya currently, we have many initiatives geared towards production of interactive digital content in different disciplines. Development and use of digital content is taking route and growing very fast. Several local publishers have started to venture in the arena of digital content development in Physics.

Physics content comprises of facts, laws, theories and principles. Some of these facts, laws, theories and principles are abstract and hence the need to use animations which can assist the learners in visualizing the abstract areas of the content. There are various multi-media elements which can be used to make the content interactive and interesting to the learner. These multi-media elements include: animations, videos, photographs, illustrations, text and sound files. For the quality of learning to be achieved while using these materials, each of the multi-media elements has to serve its intended purpose.
The elements should be correctly positioned. High quality content should have multimedia elements which are relevant and related to the content presented at any one given point. The elements should contain features which make the content interesting and interactive. The elements should also contribute to the understanding of the text. In addition to these, the multimedia elements should not distract the user of the content. The elements should be varied and adequate. Adequacy is determined by the amount of text in the material. The elements should also be clear, make proper use of colour and done proportionately. In addition to this, they should be well captioned and labeled. The aspect of sound is also key in digital educational materials. Sound files should be embedded at their correct positions within the platform. Sound should be properly synchronized with all the elements be it animations, videos or the text being read. Developers of these materials should make use of appropriate sound effects where they are deemed necessary. The voiceovers should have proper pronunciation, proper articulation, intonation and they should also have an appropriate pace of reading depending on the level of the learners who will be using the materials.

This study focused on the effect of the animations embedded in Physics interactive digital content. They are supposed to be of high quality, accurate and interesting to the learners. They should also be relevant to the concepts, laws, principles and theories they are addressing. Quality animations should have these attributes for learners to be able to visualize, understand the content well and create their own knowledge hence changing the instructional process towards constructivism. Few studies have been done in Kenya to establish the effect of using content with animations. It was against this background that this study sought to find the effect of animations embedded in e-learning materials on performance of learners in Physics.
1.2 Statement of the Problem

Materials developed for instructional purposes must serve the purpose of enhancing the teaching and learning process through transmission of knowledge, skills and the desired attitudes to the learners. The content contained in them therefore has to be designed in such a way that it aims at attaining this overall objective. E-learning materials are supposed to assist in improving the quality of education (Garrison, 2002). Multimedia elements are embedded in the content to increase its interactivity, make learning interesting and at the same time assist in helping the learners to understand difficult concepts. Dickerson (2001) argues that multimedia presentation, development, internet-based learning and access to distant resources can spark student’s learning.

As earlier stated, KICD has already developed digital content in twelve subjects at secondary school level. In all the subjects developed, the effect of the multimedia elements has never been ascertained by other educational stakeholders. A related study which has been carried out so far by KICD was done to monitor the use of digital content in ESP schools. The objectives of this KICD study were to assess the availability of digital content, establish utilization levels of KICD digital content, establish extent to which training received from the ICT champions enabled teachers to use digital content, find out extent to which ESP schools are using available infrastructure to access other educational learning resources, establish challenges being experienced by ESP schools in utilizing KICD digital content and find out teachers’ and learners’ opinions on the quality of KICD digital content (KICD research report series No. 113, 2013). Among the objectives of the study conducted by KICD, none dealt with the effect of the animations embedded on the content learners were using. Besides this, as at the time of
undertaking this doctoral study, there was no study conducted in Kenya on effect of animations in e-learning materials on secondary school students’ performance in Physics. This was identified as an existing gap which needs attention to facilitate continuous improvement of the developed content. This study sought to establish the effect of animations in the teaching and learning process in order to develop an instructional model for using animations in Physics Education.

1.3 Purpose of the Study

The purpose of this study was to determine the effect of animations used in the KICD developed e-learning materials on students’ performance in Physics.

1.4 Objectives of the Study

The objectives of this study were:

a) To determine the influence of instructional values inculcated by animations embedded in Interactive Digital Content (IDC) on performance of learners in Physics.

b) To determine the effect of animations on the concentration span of learners while learning Physics.

c) To find out if animations enhance conceptual understanding of text within the Physics interactive digital content.

d) To develop an instructional model for teaching using ICTs in Physics education.
1.5 Hypothesis of the Study

\[ H_{o1} \]: There is no significant difference in performance for learners who use e-learning materials with animations and those who use e-learning materials without animations

1.6 Significance of the Study

Findings from this study will be of help to curriculum developers at KICD and other interactive digital content developers. The multi-media developers will also benefit out of the findings since it is assumed that they will be able to develop high quality multi-media elements. Quality assurance and standards officers in the Ministry of Education will benefit by getting to know the characteristics of quality educational animations bearing in mind that they are the custodians of quality in the entire education system.

The findings will also benefit teachers and learners to a great extent. They will be able to select high quality digital content for use during teaching and learning. Trainers of pre-service teachers will also benefit since they will be in a position to guide teacher trainees in selecting appropriate digital teaching resources.

1.7 Scope and Limitations of the Study

This study confined itself to effect of animations embedded in interactive Physics digital content developed by KICD. The study narrowed down to focus on the effect of animations only while leaving out other multimedia elements like illustrations, photographs, audio and videos which are constituent parts of interactive digital content.

It was done with Physics learners from four (4) sampled secondary schools which were given computers and interactive digital content among other resources from the Economic Stimulus Programme (ESP). The four secondary schools are within Nairobi County.
In addition to this, the study focused on some selected Physics subject teachers since it was not possible to conduct the study with all Physics teachers in the sampled schools. Teachers of Physics were selected because they understand the subject matter better and they had the potential of assisting the researcher in attaining the objectives of the study. Only Form Three students were targeted for reasons given in chapter three of this thesis.

This study was conducted in only one of the Kenyan counties. To conduct the study in several counties and schools, several Digital Versatile Disks (DVDs) with content required to be produced. Production of these DVDs with some having animations and others lacking is a technical process which consumes a lot of resources and time during the preparation process. This in a way limited the study to only one county where four schools were sampled and used for the purposes of conducting the study.

1.8 Basic Assumptions of the Study

The first assumption made while conducting this study was that teachers and learners were able to navigate through the digital content with ease. The technical design of the interactive digital content has enough navigational aids. These are buttons for moving forward, backward, replaying among others. Teachers and learners are expected to be able to move back and forth with ease.

Secondly, it was assumed that the sampled schools had adequate ICT infrastructure to enable learners make maximum use of the e-learning content. Interactive digital content is accessed better through the use of computing devices. Maximum interaction of the IDC by learners is made possible when the ratio of the computing devices to the learners is 1:1.

In addition to this, it was also assumed that learners given content without animations did not get access to content with animations. Access of content with animations by learners from the
control group would affect the study in a negative way and the effect of the treatment would not be observed with the required accuracy.

Lastly, it was assumed that learners from control and experimental schools did not discuss any details of interactive digital content used for instructional purposes in their respective schools. Interaction of learners from the experimental group and subjects from the Control group would give an opportunity for learners in both groups to discuss the IDC and hence chances of affecting the observations made during the post-test would be very high. This would affect the attainment of the study objectives.

1.9 Theoretical Framework

This study was guided by the Dual Coding Theory (DCT). Dual coding is a theory of cognition introduced by Allan Paivio in late 1960s. It suggests that there are two distinct sub-systems contributing to cognition. One is specialized for language and verbal information and the other for images and non-verbal information. The theory further indicates that human cognition is unique in that it has become specialized for dealing simultaneously with language and with nonverbal objects and events (Paivio, 1971). The most general assumption in DCT is that there are two classes of phenomena handled cognitively by separate sub-systems, one specialized for the representation and processing of information concerning nonverbal objects and events, the other specialized for dealing with language (Paivio, 1990). The verbal and non-verbal processing systems are functionally and structurally independent. This means that each of them can work independently of the other one and that they work on different kinds of representational units. According to Ryu, Jiyeon, Lai, Colaric, Cawley, and Aldag (2000) representational units are relatively stable long-term information corresponding to perceptually identifiable objects and
activities both verbal and nonverbal. They are divided into logogens and imagens. Logogens are verbal entities and this can be in the form of spoken or written words and organized in terms of associations and hierarchies. Imagens are mental images and non-verbal entities and they are organized in terms of part-whole relationships.

In the DCT, Paivio also addressed the issue of individual differences in tendency and capacity to use imagery by indicating that learners who have trouble imaging can fail to remember text that is easily remembered through imaginal processing. Such learners may not understand Geography or other spatial facts in a concrete way and might do poorly at visualizing the steps in a geometric proof, spelling difficult words or even printing letters correctly (Paivio, 1965).

DCT in the practical sense suggests that combining verbal and graphical material in learning increases the probability that words will activate corresponding images and vice-versa. Combination of verbal and images assist learners in generation of appropriate mental images. It is worth noting that learning material becomes easier to relate if it is less abstract. These mental images are similar to the schemas Piaget proposed in his cognitive learning theory and they help learners in storage and retrieval of knowledge.

Multi-media elements have the capacity to assist learners form mental images during the teaching and learning process. Use of quality animations assist learners in forming the mental images which can be transformed into relevant imagens. Imagens are like schemas and they help learners in the representation of a plan, theory or concept in the form of an outline or model. Simulations embedded in interactive digital content help learners to form mental images in their minds with much ease. Quality animations have the capacity to assist learners
in comprehending abstract concepts and at the same time, help them to store the acquired knowledge in the long-term memory (Hewson, 2002). Animations are very important in the teaching and learning process. Proper use of animations provides a learning environment that helps learners to conceptualize concepts in a better way. Effective application of animation during the teaching process depends on the teachers’ knowledge on the principles and practice guiding its application, the characteristics of the learners and the objectives of the lesson (Kwasu A. & EmaEma, 2015). In highlighting the importance of animation in the instructional process, Steward (2002) indicated that the role of animation in the instructional process is rapidly becoming one of the most important and widely discussed issues in contemporary educational circles. Okon (2008) reporting on the state of animation in teaching and learning activities in schools indicated the unfortunate situation where it was seen simply as medium of entertainment. It was further noted that the importance of animation in educational process is quite evident. Animation plays a great role in the instructional process and has dominated the instructional practices in recent times.

The mental images formed further assist the learners to recall and retrieve stored information and this helps in making their performance in Physics and any other discipline better. This study sought to determine the effect of animations used in Physics interactive content developed and produced at KICD.

1.10 Conceptual Framework for the Study

According to Driver, Asoko, Leach, Mortimer and Scott (1994) conceptual framework refers to the mental system of organization which individuals impose on their sensory inputs and which is indicated in their responses to specific problems or problematic situations. The conceptual framework of this study is based on its theoretical framework. Physics content consists of concepts, laws, theories and principles. Sometimes, these concepts, laws, theories and principles
are abstract. They need to be simplified for the learners to be able to conceptualize them with much ease. One way in which the e-learning materials ensure that the learners conceptualize the contents of a subject with ease is by using multimedia elements like animations, videos, illustrations and sound. In this study, focus was on the animations used and how they help the learners to form imagens so as to understand Physics laws, theories, concepts and principles without misconceptions. Once imagens are formed, they assist the learners in storing the acquired knowledge and skills. They further help the learners to retrieve the stored information with much ease. This line of thinking is basically what was championed by Allan Paivio when he came up with the DCT.

Figure 1.1 is a diagrammatic representation of the independent variables and the dependent variables which were the main focus of this study. The independent variables are the various Physics concepts in e-learning interactive content, teacher ICT skills, teaching methods, teaching strategies, school support for use of ICT tools in teaching and motivation of the learners. The dependent variable was learner’s performance in Physics. The intervening variables were learner’s attitude towards Physics, teacher’s attitude towards Physics, Physics teacher’s experience and the school environment including support from the school administration concerning the use ICTs during the teaching and learning process.
Figure 1.1: Conceptual Framework for the study

When Physics teachers use teaching resources with animations during the teaching and learning process, it is expected that the Physics learners understand the concepts being taught with much ease and they later store the acquired knowledge in their long-term memory. It is assumed that this leads to improved student performance in Physics. On the contrary, when Physics teachers teach using Physics instructional resources lacking animations, Physics learners are more likely to demonstrate a relatively poor performance.

1.11 Definition of Key Terms

Animations - Simulated motion pictures showing movement of drawn objects.

Concentration span - Time taken to undertake a mentally challenging activity.

Construct validity - The degree to which a test or other measure assesses the underlying theoretical construct it is supposed to measure.
Content validity - The extent to which an instrument or research tool measures what it is intended to measure.

Digital content - Information that is published or distributed in a digital form, including text, data, sound recordings, photographs and images, motion pictures and software that are available for downloads or distribution on electronic media.

Direct teaching method - A method that is suitable for memorizing basic information and mastering of well-defined performance skills.

ICT Champion - A person who offers high level leadership in ICT integration in education through provision of oversight, training, inspiration, mobilization of resources and general goodwill to see to it that ICT related initiatives succeed.

In-direct teaching method - A learner centered approach to education that facilitates practice of a range of skills and encourages learners to take responsibility of the enquiry process.

Economic Stimulus Programme - A programme of economic reform measures put together by a government to revive and stimulate a struggling economy

Form I - The first year of secondary school level of education in Kenya.

Form II to IV are the subsequent higher levels of secondary education in Kenya.

Learning Content - Software for authoring content. It may be solely dedicated to
Management System producing and publishing content that is hosted on a Learning Management System or it can host the content itself.

Learning Management System - Software used for delivering, tracking and managing training and education. For example, tracking attendance, time spent on task and learner’s progress.

Schema - A set of linked mental representations of the world, which we use both to understand and to respond to situations. They are “units” of knowledge, each relating to one aspect of the world, including objects, actions and abstract concepts.
CHAPTER TWO
REVIEW OF RELATED LITERATURE

2.0 Introduction

In this chapter, the literature related to the study was reviewed. The review included importance of animations in learning, effect of animations on conceptual understanding of content, effect of animations on concentration span of learners, related theories of learning, multimedia elements used in digital educational materials, policies on ICT integration in education and conclusion of the chapter.

2.1 Effect of Instructional Values Inculcated by Animations

Animation refers to simulated motion pictures showing movement of drawn objects (Musa, Ziatdinov and Griffiths, 2013). It is a method in which images are manipulated to appear as moving images. Mayer and Moreno (2002) state that animation is a form of pictorial presentation and it refers to computer-generated motion pictures showing associations between drawn figures. Things which correspond to this idea are motion, picture and simulation. Animations are different from videos and illustrations in that the latter consist of motion pictures depicting movement of real objects. Computer animation brings inanimate objects to life by adding motion onto them. Animations are categorized into either two-dimensional or three – dimensional. Both two – dimensional and three-dimensional animations are geared towards improving learners’ achievement level. Achievement level is the cumulative performance of a learner, displayed in competencies to demonstrate a specific skill or knowledge actualization (Achuonye, 2011). Animations help learners in visualizing abstract concepts presented in the subject matter of a given learning area.
The role of the teacher when using ICT in the learning process is to assist in the transfer of knowledge to learners in a meaningful and understandable manner (Sturmer, Konings and Seidel, 2013). Teachers often employ specific strategies to create and transfer knowledge and one such technique they use is visualization (Strakhovich, 2014). Visualization involves use of images to transfer data, information or knowledge (Ursyn, 2018). Visualizations help learners in co-creating their own learning experiences. In addition to this, involving learners actively in knowledge visualization is one way of compelling them to engage with learning material and to achieve knowledge transfer. Furthermore, producing knowledge visualizations allows learners to demonstrate their knowledge acquisition. Animations help learners in creating these visualizations. The visualizations help learners in storing knowledge in the long term memory. They also help in retrieving the stored information when needed.

Instructional values affect the way instructors teach, what they expect of their learners and what they expect of themselves as teachers. Teachers who want to improve their teaching effectiveness must be assisted in recognizing their own instructional values. The instructional values include interest and motivation. They apply to both learners and teachers. Animations have the capability of increasing interest and motivation levels of both teachers and learners during the instructional process. When interest and motivation levels of both learners and teachers are increased during the learning process, performance of learners is increased. This has been evidenced through various studies.

Musa, et al. (2013) studied the instructional value of animation which has become a prominent feature of technology -based learning environments. The findings of the study revealed that educational computer animation has turned out to be one of the most elegant tool for presenting
multimedia materials for learners and its significance in helping to understand and remember information has greatly increased since the introduction of powerful graphics-oriented computers. Learners who used content with animations were highly motivated.

Gambari, Falode and Adegbemro (2014) studied the effect of computer animation and geometry instructional model on Mathematics achievement and retention of Junior Secondary School learners in Minna, Nigeria. The findings indicated that learners taught geometry using computer animation performed significantly better in post-test and retention test than their counterparts taught geometry using instructional model and traditional method respectively. The interest in learning for learners who were presented with computer animations was greatly increased. These findings indicated that geometry concept in mathematics could be taught and learnt meaningfully through the use of computer animation.

Yigal (2009) studied the effects of an animation-based on-line learning environment on transfer of knowledge and on motivation for Science and technology learning. The study revealed that there was a significant impact of animation-based on-line learning environment on transfer of knowledge and on learning motivation. Moreover, the findings showed that learners changed their perception of Science and Technology learning as a result of teaching and learning with integrated animations. Students perceived themselves as playing a more central role in classroom interactions, were more interested and more motivated in learning and emphasized on the use of technology and experiments during lessons more.
Adegbija & Falode (2014) conducted a study on the effect of animation-based camstudio Physics instruction on secondary school students’ performance in Minna, Nigeria. The findings of the study revealed that animation-based camstudio Physics instruction improves students’ achievement scores in Physics. It increases motivation of learners while learning and this leads to increased interest. Students taught Physics using animations performed significantly better than their counterparts taught Physics using conventional lecture method.

Across the globe, the use of animations and education technology in the learning process is to give enough emphasis on the facts being learned. According to SerDn (2011) incorporating more educational technology such as animations and computer-based simulations is of ever increasing importance because federal legislation mandates an emphasis on technology integration in all areas of basic education. Under this mandate, education leaders and managers at the state and local levels are expected to develop plans to effectively utilize educational technologies such as animations in the classroom. Rosen (2009) points out that using educational technologies such as animations, interactive computer programs and various other technologies throughout instruction increases learner’s understanding and achievement in content knowledge. Few studies have been done to establish the role played by animations in the learning of Physics. This gap was identified and this study sought to establish the value animations add to the learning of Physics content.

2.2 Effect of Animations on Concentration Span

The academic lives of our learners are often reflected through challenging and complex interactions of the cognitive, affective and behavioural aspects, such as beliefs, values, interest, motivation, engagement and persistence towards learning and performance (Ramma, Bholoa,
Watts and Nadal, 2018). Wang & Reeves (2007) believe that what educators do to help students actively engage in learning may be more important to academic success than how much information is presented to them through instructional materials or other forms of instruction. Physics teachers have to use constructivist – based pedagogies while teaching using animations. Alsulami (2016) asserts that use of constructivist – based approaches while teaching changes the way of thinking among learners and increases the motivation for learning when applied gradually. The use of educational technology in the Science classroom not only helps with student understanding of content, but also positively impacts students’ engagement in lessons and their attitudes towards learning (Shu-Nu, Yau-Yuen & May, 2009). According to Wieman, Perkins, Adams and Oersted (2008) Physics subject matter can be understood with the help of animations. Experimental activities that are difficult for students to understand are made simpler and easier to understand with the help of animations. Animation offers an ideal, dynamic, visual representation of existing phenomena and makes Physics experiments easier without being done in a school laboratory. The use of simulations on Physics subject will be more enjoyable and will not make students bored in monotonous learning (Rutten, Joolingen and Veen, 2012).

According to Shu-Nu, et al. (2009) research has showed the importance of cultivating students’ learning interests about Science, student motivation level and their relationship to learning achievement. Computer-based simulations allow students to work in a dynamic interactive environment which facilitates their knowledge reformulation and concept attainment besides evoking and sustaining interest, concretizing learning and making learning less stressful (Wang and Reeves, 2007). Ramsden (1998) drew the conclusion after doing his study and indicated that
learners have generally held unfavorable attitudes and beliefs towards Science. Osborne, Simon & Collins (2003) confirmed this finding through a comprehensive review of literature and concluded that to remediate the continuing decline in the number of students pursuing further study in Science, teachers need to revisit their teaching and learning activities with a view of revising them so that learners’ motivation and concentration span in Science-related activities is increased reasonably.

According to Wang and Reeves (2007), one strategy used to enhance the active engagement of students as they learn Science is to design the computer – based animations with four intrinsic motivational strategies namely challenge, curiosity, control and fantasy. To start with, the component of challenge is taken care of by ensuring that animations have engaging activities that challenge the learners’ abilities and this enhances their intrinsic motivation. Curiosity is stimulated by using technical events within the animations to attract the learner’s attention. Control is taken care of by developing animations which provide learners with an opportunity to direct their own learning. Lastly, fantasy is taken care of by providing an environment that evokes mental images of physical or social situations not actually present or in some cases not possible. These four factors are believed to enhance intrinsic motivation and extent the concentration span of learners if incorporated in a computer-based simulation. Huppert, Lomask & Lazarowitz (2002) affirmed that computer simulations can positively influence students’ satisfaction, participation and initiative and improve their perception of the classroom environment. Olsen and Clough (2001) state that simulations fascinate students and have the capability of grabbing and maintaining their attention in ways that interacting with a teacher,
reading a book, seriously discussing ideas with other students and thinking about their own learning cannot. Animations designed and developed with these four components have the potential of extending the learner’s concentration span. Few studies have been conducted to establish whether using Physics content with animations extends the concentration span of learners. This study also sought to establish this.

2.3 Effect of Animations on Conceptual Understanding

In constructivist views of learning among current Science education researchers, learners enter Science classrooms with prior knowledge or conceptions about the physical world before they ever receive formal instruction. In general, teachers encounter a variety of learners’ conceptual information which often is incomplete and contrary to accepted scientific knowledge, or at variance with scientifically accepted norms, formally called misconceptions or alternative conceptions, mostly based on their prior knowledge (Driver and Oldham, 1986). To be able to successfully restructure their concepts in Science, learners need to link newly constructed scientific ideas to their pre-existing concepts, refining or dismissing them in the case of incommensurability. Researchers in Science education have concentrated on investigating theories and ways to facilitate the understanding of scientific concepts and bring about conceptual change (She, 2004).

Concurrent with the rapid growth of computers and technologies in the practice of, and progressive developments in, the Science education community, contemporary technology-based approaches to Science learning offer computer simulations with ample opportunities
for students’ inquiry-related learning environments for conceptual change (Rutten, van Joolingen and van der Veen, 2012; Srisawasdi and Kroothkeaw 2014; Vreman-de Olde, de Jong and Gijlers, 2013). Computer simulations are programs that contain a representation of an authentic system or phenomenon and they have a number of features that are of particular help in the teaching of Science (Blake and Scanlon 2007; Wellington, 2004). Currently, inquiry-based learning with computer simulations is generally seen as a promising area for conceptual change in Science (Smetana and Bell 2012; Srisawasdi and Kroothkeaw 2014; Srisawasdi and Sornkhatha 2014). Physics is a Science subject and teaching it using animations can also lead to a significant conceptual change. Computer animations offer many attributes that are potentially useful for promoting cognitive dissonance and inducing conceptual change (Rutten, et al., 2012). To address the issues of conceptual understanding during the learning of Physics, use of animations has been used as a pedagogical approach for enhancing students’ conceptual learning and development in school Science.

Science classes should strongly emphasize on incorporation of educational technologies such as animations, interactive computer programs and other technologies into the classroom (Swain, 2012). According to Nurul, Jumadi, Wilujeng, and Kuswanto (2019) students do not understand concepts in Physics if there is no direct demonstration through which they observe. Physics subject content can be understood easier with the help of animations. According to Perkins, Adams, Dubson, Finkelstein, Reid and Wieman (2006), animations are designed to facilitate teaching and learning through visualization and interacting with them helps in understanding Physics concepts clearer. The use of animations and computer based simulations throughout instruction increases student’s understanding and achievement (Rosen, 2009). Becker (1986)
found that the use of computer-assisted learning improved the academic performance of below-average and average students in the middle school.

Studies have shown that instruction in a Science classroom should ensure that learners are actively engaged in the material for maximum achievement of learning outcomes to take place (Swain, 2012). Learners should be able to take concepts from the Science classroom and apply them in real-life situations. Use of IDC with animations can help learners in making this connection happen more effectively than through the use of traditional instruction. The incorporation of computer animations provide enhancement and relevance to Science learning. Rieber (1994) indicates that computer animation, in particular, is a new educational tool that fosters long-term learning by calling attention to objects during the early steps of instruction. According to Shu-Nu, Yau-Yuen & May (2009) the use of animations in the Science classroom not only helps with learner’s understanding of content but also impacts positively on the learner’s engagement in lessons and their attitudes towards learning.

According to Swain (2012), in all Sciences, but particularly in earth Science, learners hold deeply rooted misconceptions. These misconceptions are highly attributed to misrepresentation in textbooks and various other instructional materials used during the learning process. A study done on earth Science content in all secondary schools in England and Whales revealed that Science textbooks and related publications used had many errors and misconceptions (King, 2010). More than 500 instances of misconception were identified through this study. Using appropriate representations through animations and computer simulations help to dispel these deeply rooted misconceptions and in correcting the errors. However, it is worth noting that the
role of animations and computer simulations must be defined in for such technologies to be used to dispel misconceptions and increase student achievement and understanding. According to Barak, Ashkar, and Dori (2011) an animation is conceptualized as the act, process, or result of imparting life. In the context of learning, animation is effective especially in visualizing processes that cannot be seen or that are difficult to explain in class.

Animations are images in motion and they can combine several multimedia elements. According to Gardner (1993), learners have multiple intelligences and not all students learn best through traditional teacher–centered verbal instruction. There is therefore need for teachers need to expand their repertoire of teaching tools and strategies, breaking free from the traditional linguistic and logical approaches. Akpinar and Ergin (2008) point out that animations stimulate more than one sense at a time and therefore make learners more attentive during the learning process. They also help learners in retaining more of what is learned. Sulaiman (2011) notes that the use of visual animation and interactive simulations can serve not only as a specific remedy to one-sidedness in teaching, but also as an organizational tool that facilitates and complements existing educational pedagogy. The use of interactive simulations such as animations is an approach to teach learners with learning difficulties because it requires active participation, is multi-sensory in nature and has the ability to stimulate the interest of all learners. Swain (2012) asserts that the strategy used during instruction in a Science classroom should engage learners actively in order for maximum achievement to occur. Learners need to be able to take concepts from the Science classroom and apply them to their everyday lives. The incorporation of computer animations and models provide enhancement and relevance to Science learning.
Several studies have been done to establish how computer animations affect learner’s content knowledge and achievement. Udo & Etiubon (2011) investigated the relative effect of computer-based Science simulations on learners’ achievement at the secondary school level when compared with traditional expository teaching methods. The pre and post test scores showed that learners taught by computer-based Science simulations performed significantly better than those taught using the traditional expository method.

Srisawasdi and Panjaburee (2015) conducted a study on the effect of simulation-based inquiry integrated with formative assessment on students’ conceptual learning of buoyancy-driven phenomena. In this study, students’ conceptual learning performance from two Thai public schools collected in two studies was examined. The findings indicated that students’ understanding of buoyancy-driven concepts made continuous progress throughout the learning of the simulation – based inquiry coupled with formative assessment approach from pre-test to post-test and post-test to retention-test. This indicates that use of simulation – based inquiry successfully promoted students’ conceptual change.

Huppert, Lomask, & Lazarowitz, (2002) investigated the computer animations’ impact on students’ academic achievement and their mastery of Science process skills in relation to their cognitive stages. The study revealed that simulated experiments have great potential to address the problem solving process which is a complex activity. The findings showed that the concrete and transition operational learners in the experimental group achieved significantly higher
academically than their counterparts in the control group. Learners’ academic achievement indicates the potential impact a computer simulation program can have. Simulations enable learners with low reasoning abilities to cope successfully with learning concepts and principles in Science which require high cognitive skills. A computer simulated experiment addresses the problem solving process by controlling the input values of a model, describing its changes through time, and examining the changes in the outcomes. The integration of short simulations into the existing curriculum of heterogeneous classes in which learners are at different cognitive stages can lead to an improvement in the level of attainment of their learning outcomes.

Jimoyiannis and Komis (2001) examined the effect of using computer animations on learners’ understanding of basic kinematics concepts concerning simple motions through the Earth’s gravitational field. The findings revealed that computer simulations led to an increase in learner’s content knowledge. This was done by comparing a group of learners who received traditional classroom instruction with a group of learners who were exposed to both traditional instruction and computer animations. Learners who used the computer animation in addition to traditional instruction achieved significantly higher results on the research tasks. The study recommended that computer animations can be used as a complement to other forms of instruction in order to facilitate learners’ understanding.

Rivers and Vockell (1987) point out that computer animations have been found to enhance learners’ active involvement in the learning process, enabling them to apply principles more
often, and helped learners to meet the learning unit goals. Learners who used the guided version of the animation performed better in the tests of scientific and critical thinking than the learners in the control group.

Ummeh and Fawzia (2014) examined the effect of using computer animation in teaching Chemistry at Advanced level. During the study, an attempt was made to enhance students’ conceptual understanding of the “Chemistry of Life” through use of computer animations. The findings revealed that use of computer animations has a positive impact on students’ motivation, interest and engagement, leading to enhanced conceptual understanding. Further, it was found that “cues and labelling”, proper design in terms of colour and graphics, as well as embedded “voice questions” can all play a crucial role in helping learners to retrieve information from computer animations, and, to develop understanding of the concepts under study. In addition to this, the findings also indicated that learner-controlled interactive computer animations are most effective in enhancing students’ motivation, interest, and conceptual understanding as compared to non-interactive ones. There is fairly extensive literature arguing that animations are more effective than static sequential images for teaching dynamic events (Pollock, Chandler and Sweller, 2002).

Some prior knowledge learners have about Physics subject matter has some misconceptions. Quality animations are supposed to assist learners in the process of removing these misconceptions by putting Physics concepts, laws, theories and principles in the correct
perspective. Few studies have been conducted to establish the effect of animations on conceptual understanding of facts, theories and principles in Physics.

2.4 Related Theories of Learning

Learning itself is a process which pulls together emotional, cognitive, environmental factors and experiences in order to acquire, enhance, and make changes to an individual's skills, knowledge, values and views. Learning theories are conceptual frameworks that describe how information is absorbed, processed, and retained during learning (Illeris, 2004). Cognitive, emotional and environmental influences, as well as prior experience, all play a part in how understanding or a world view, is acquired or changed and knowledge and skills retained (Ormrod, 2012). Lee (2006) states that it is important to review theories of learning because they provide conceptual tools to be used by teachers when thinking about teaching. The theories discussed in this section are closely related to how students learn by constructing their own knowledge. This kind of learning takes place when the learning environment is carefully designed taking care of resources, relevant assessment strategies and use of inquiry based learning approaches.

According to Bruner (1966) a theory of instruction should address four major aspects which are predisposition towards learning, the ways in which a body of knowledge can be structured so that it can be grasped most readily by the learner, the most effective sequences in which to present material, and the nature and pacing of rewards and punishments. Good methods for structuring
knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information.

As such, Physics content should be presented in such a manner that learners can easily understand the concepts, theories, principles and laws therein. The packaging should follow the most effective theories of learning which are assumed to produce the highest number of the desired outcomes. These are the basis on which instructional design principles are founded. For the purpose of this study which focuses on effect of animations used in interactive digital content, cognitivism and constructivism are hereby discussed in detail because they inform teaching and the use of different instructional resources including technology.

2.4.1 Constructivism Theory of Learning

The main proponents of the constructivist learning theory include Jean Piaget, John Dewey, Lev Vygostky and Jerome Brunner. The theory is founded on the premise that learners reflect on their experiences and thereafter construct their own understanding of their world (Driver, et al., 1994). Constructivism focuses on how learners construct their own knowledge. Jean Piaget defined accommodation and assimilation as ways in which new knowledge is built upon previous knowledge and how educational media assists learners during the processes of accommodation and assimilation. The learners generate their own rules and mental models, which they use to make sense of their experiences. Learning is therefore the process of adjusting the mental models to accommodate new experiences.

Constructivists view teachers in Science classrooms as authority figures who play two essential roles. The first one is to introduce new ideas, provide support and guide learners to make sense of the new ideas for themselves. The other one is to listen and diagnose the ways in which the
instructional activities are being interpreted to inform further action (Driver, et al., 1994). Teaching approaches used in Science education should focus on providing learners with physical experiences that induce cognitive conflicts and hence encourage them to develop new knowledge schemas that are better adapted to experience. Animations help learners in creation of the schemas. They challenge learners to be creative in terms of constructing their own knowledge in addition to making abstract concepts clear. When learners are given opportunities to actively construct their knowledge in a certain discipline, deep understanding is more likely to develop (Krajcik, Blumenfeld, Marx, Bass, Fredericks and Soloway, 1998). Perkins (1993) argues that engaging learners in thought-demanding performances provides opportunities that promote deep understanding. This performance perspective suggests that learners construct knowledge by engaging in learning activities that require them to explain, muster evidence, find examples, generalize, apply concepts, analogize and represent knowledge in a new way as they create new understanding that builds on their prior knowledge.

Constructivism emphasizes the importance of the active involvement of learners in constructing knowledge for themselves and building new ideas or concepts based upon current knowledge and past experience. Illeris (2004) asserts that discovery, hands-on, experiential, collaborative, project-based and task-based learning are a number of applications that base teaching and learning on constructivism. Animations embedded in the interactive digital content has technically designed prompts which lead learners towards becoming active learners as they interact with them while doing the in-built hands-on activities.
Alsulami (2016) asserts that constructivism is one of the effective theories that demonstrates an explanation of learning as a self-regulated process where learners can build on their existing knowledge and should be active participants. Constructivism is a collaborative process including social factors, interactions with surrounding environment and self-reflection. Constructivist learning theory involves several versions which are related and all these forms together can work to enhance the learning process and education in general.

Dale (1969) concludes that learners retain more information by what they “do” as opposed to what is “heard”, “read” or “observed”. His research led to the development of the cone of experience (Figure 2.1). Today, learning by doing is what is known as experiential learning or action learning. Learners generally remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they say and write and 90% of what they do as they perform a task.

**Figure 2.1: Dale’s cone of experiences**  
(Source: Adapted from Edgar Dale, 1969)
The least effective method at the top, involves learning from information presented in print format (Dale, 1969). The most effective methods involve direct, purposeful learning experiences such as hands-on activities or field experience. Direct purposeful experiences represent reality or things that are closer to reality and the ones we often come across in our everyday life. The cone also illustrates the average retention rate for various methods of teaching. Towards the bottom of the cone, greater learning and higher retention of the information learned takes place. It also important to note that when using an instructional method it is important to always remember that involving learners in the process strengthens knowledge retention. It reveals that action-learning techniques result in up to 90% retention. From the findings of Dale’s research, people learn best when they use perceptual learning styles. Perceptual learning styles are sensory based. The more the sensory channels engaged by the learners when interacting with a learning resource, the higher the chance of learning meaningfully from it. Quality animations are supposed to be highly interactive. They combine visuals, text and navigational tools which give the learners an opportunity to adequately interact with them. The interactivities in the animations should give learners many opportunities of engaging their hands and mind through physical and virtual manipulations. Interactive learning takes place in a learning situation where a learner and a computing device are actively and mutually responding to input or output and adapting to responses (Jonassen, 1999).

Islam (2019) conducted a study to examine the theory and practices of communicative language teaching where English was investigated as a foreign language in the classroom. The study was designed to investigate the extent to which constructivist-based approaches of teaching and learning were being used in higher secondary education in Bangladesh. During the study, constructivism learning theory was applied to develop communicative competence among the learners. Though the national curriculum of Bangladesh had applied
communicative learning theory in its schools for decades, still, students' competence in using the English language for communication purposes was way below expectations. As an intervention measure, constructivism theory, scaffolding and cooperative learning strategies, lesson plans were prepared for the students of eleven grade in Bangladeshi college. After lessons were conducted using these interventions, learners were able to meet expectations in terms of their communicative competencies using English.

Constructivist approaches of teaching and learning lead better results in terms of attainment of learning outcomes when the learning resources to be used are well thought out and designed. Youngmi and Jinju (2015) conducted a study which sought to investigate the self-images of Science teaching held by early childhood pre-service teachers who took constructivism early childhood Science education courses. The study also sought to analyze the aspects of the courses which influenced these images. The purpose of this study is two-fold. The results showed that four participants who displayed teacher-centered images before taking the courses changed to child-centered images after the courses. The factors that influenced those images were changed perspectives of a teacher's role and experiences of constructivism-based Science teaching for young children. The other four pre-service teachers who held child-centered images before the course solidified child-centered images after the course. The influences on those images were learner-centered learning experiences and experiences with constructivism-based Science teaching for young children. This result implies that early childhood Science education should provide opportunities for pre-service teachers to reconstruct their own views about Science teaching in order to learn and teach based on constructivism. Quality animations have attributes which ensure that the learning
process is learner-centred. Physics teachers should combine use of quality animations with the relevant constructivist – based approaches for effective learning to take place.

According to Dewi and Muhammad (2016) teaching materials should be prepared by using a constructivism approach where learners build or find concepts in a certain learning area on their own. These teaching materials should prompt learners to work and acquire knowledge by themselves. It is worth noting that learners make meaningful use out of learning materials which enable them to acquire new knowledge.

Constructivism has numerous benefits when used for teaching and learning purposes. Savaş (2016) indicates that constructivism takes learners’ prior knowledge into account. Teachers seek to know what learners already know as they teach something new. This new knowledge acts as a bridge to the new knowledge. It also encourages environmental and social interactions. It also considers learners’ errors as opportunities for learning. This is contrary to assumptions made when traditional methods of learning are used where learners are rebuked for making errors during the learning process. Instead of condemning learners after making errors, it uses the mistakes they make as learning opportunities. Constructivism ensures that learners take the centre stage during the learning process. Learning activities are designed with the learner in mind and the teacher as a guide or facilitator. When learners are engaged in doing the designed activities, they acquire problem solving skills. Constructivism also ensures that learners are challenged to interpret and elaborate the observations they make during the learning process. Animations designed with a strong foundation on constructivism ensure that learners benefit from all these. When learners interact with such animations, they become critical thinkers, collaborators, problem solvers and innovators. Williamson and Abraham (1995) contend that computer-aided environments help learners in terms of making their problem solving skills better, boosting their imagination capabilities and helping them to achieve learning outcomes with much ease.
The findings from a study conducted by Dewi and Muhammad (2016) showed that teaching materials designed in the module-based constructivism were able to effectively improve student learning motivation while learning Mathematics. This study examined development of geometrical teaching materials based on constructivism to improve the students’ Mathematics reasoning ability through cooperative learning jigsaw at the class VIII of SMP Negeri 3 Padangsidimpuan. The findings of this study strengthen the results of research done by Cakir (2008) who found out that teaching materials in the form of module-based constructivism are valid, practical and can effectively improve student learning motivation on the subjects of Algebra II. The study also reinforces the results of a research conducted by Koray (2013) who found out that the reasoning abilities of students in trigonometry material can be increased through the development of quality teaching materials.

Despite the many benefits of constructivism highlighted out of research findings, it is worth noting that some teachers do not completely understand this approach. Williams (2017) conducted a research which sought to establish whether teachers of international classrooms believe in the ideas of constructivism and whether those beliefs translate into classroom practice. The findings of this study showed that most of the respondents had some beliefs consistent with constructivism but did not fully embrace the learning theory. The observational evidence supported this by failing to provide evidence of constructivist activities in the classrooms. It was concluded that most of the participants in the study do not hold beliefs consistent with constructivism and that they are not using the learning theory to empower and engage students in the learning of Science. Teachers require capacity building and support so as to successfully implement constructivism which will in turn engage and empower learners. When they teach using constructivist-based approaches using quality
animations built on the foundations of constructivism, optimal learning will take place among Physics learners. To conclude, constructivism is highly influenced by the methods we use when teaching, the quality of media used and elements embedded in it among other factors. Quality animations have interactivities which stimulate the learner’s creativity and if they are well utilized, they can help learners in becoming creators of knowledge.

2.4.2 Social Constructivism Learning Theory

This is also known as Vygotsky’s Learning Theory. Mimi (2010) indicates that Vygotsky’s theories of learning and development are grouped into four major ideas. These ideas are that: children construct knowledge, learning can lead to development which cannot be separated from its social context and that language plays a central role in mental development. These ideas are all interconnected and built upon each other.

Mimi (2010) points out that Vygotsky believed in children constructing knowledge instead of passively reproducing what is presented to them. Learning is much more than the mirroring; it always involves learners creating their own representations of new information. McLeod (2012) points out that Piaget believed that construction of knowledge occurs primarily in the child’s interaction with physical objects. Socio-constructivist theorists stress the importance of learning in social settings, where the learner is involved in testing ideas and is actively engaged in the learning process, rather than being a passive recipient of knowledge. They argued that this approach enables the learner to gain a deep understanding of the learning concepts and through discussion with others to reframe or embody the new concepts or skills. Kolb (2005) indicates that engaging learners through well-structured learning experiences can promote the higher-order
thinking skills which include analysing, evaluating and creating. Animations help learners in understanding concepts in a better way and this puts them in a platform where they can reconstruct the acquired knowledge and create new knowledge.

It is the responsibility of educators to develop critical thinking skills of their learners. Innovative and creative thinkers, who are willing to debate and test ideas, make a significant contribution to society as they are capable of solving complex problems and contributing new ideas to the society. They are also more accustomed to solving problems as part of a network and recognize that in order to solve some problems a meaningful discussion with a colleague who has prior experience can be a very valuable learning experience.

2.4.3 Cognitive Theory of Multimedia Learning

The proponent of this learning theory is Richard Mayer. Multimedia is one of the e-learning components that acts as a medium of delivering information. In education, multimedia takes different forms including words and pictures. The pictures can be presented in static form, such as illustrations, photos, diagrams, charts, maps or in dynamic form such as animation or video (Mayer, 2011). The use of instructional multimedia can also take many formats, such as students watching and listening to a narrated animation, reading a Science textbook, playing an educational video game, attending a Power-Point presentation or watching and listening to educational video. Mayer developed the Cognitive Theory of Multimedia Learning (CTML) to explain how multimedia learning works and how we can best use it. The importance of multimedia learning is well understood when we first study how the brain processes information. Mayer states that the brain takes in and processes information using several channels based on how the information is presented. The first channel is for visually represented material and the
second is for auditory represented material. According to this theory, knowledge is represented and manipulated through two cognitive channels: visual-pictorial and auditory-verbal. Animated movies are a combination of the two channels. The written text and the animated characters create the visual-pictorial channel and the characters’ voices form the auditory-verbal channel (Swain, 2012). Mayer’s cognitive theory of multimedia learning indicates that the words and visuals that we choose to use during the instructional process are important and impactful. Choosing a cartoon animation that doesn’t directly relate to the material can hinder a student’s learning rather than helping them.

This theory of learning is based 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. Mayer also came up with the multimedia principle which states that people learn more deeply from words and pictures than from words alone. It should however be noted that, simply adding words to pictures is not an effective way to achieve multimedia learning. The goal should be to use instructional media in the light of how human mind works. (Mayer, 2014). A major assumption underlying this line of work is that although humans can construct a mental representation of the semantic meaning from auditory or visual information alone, instruction that is presented in both formats, provides complementary information that is relevant to learning (Baggett, 1984).
Mohamed (2012) points out that, in the recent past, cognitive researchers have identified the main challenges facing the use of multimedia materials in the learning process. To start with, there is a challenge while using multimedia in the learning process when inclusion of extraneous content that competes with the important information for takes place when designing and producing multimedia learning materials. When this happens, learners engage in extraneous processing while using their processing capacity to attend to and process material that is not essential to building a mental model of the content to be learned. This implies that when learners are given an expanded multimedia lesson, they may have less cognitive capacity for processing the essential material and therefore may be less likely to build a learning outcome that can be used to generate useful answers on a test (Clark and Mayer, 2011).

Secondly, when multimedia learning materials are used in the presentation of lessons, they may contain some interesting but extraneous details. It should be noted that it is not possible to delete the extraneous material. In this case, it is difficult to focus learners’ attention on essential information. Instead of presenting extraneous material to learners, it is better for students to learn from a multimedia lesson when essential words are highlighted or signaled to help guide their attention toward the essential information. Highlighting can be done in different ways such as through addition of an overview sentence at the start of the narration that restates the main ideas, adding headings for each section in the narration that correspond to the main ideas in the overview and emphasizing main ideas in the narration by stressing them vocally. Empirical evidence supports these methods found in many studies involving both computer-based lessons and paper-based lessons, where learners who received signaled lessons performed better on transfer tests than students who received non-signaled lessons (Mautone and Mayer, 2001).
Thirdly, when the learning content is dynamic and too complex and the designer cannot delete the material because it is required for the learner to build a coherent mental representation. Complexity is established using the number of elements and the relations between them. This situation is likely to lead to overloading of the learner’s cognitive system by essential material and the demands of essential processing overwhelm the learner. To overcome this challenge, the multimedia content should be broken into segments. Segmentation allows the learner to fully represent each part of the presentation before moving on to the next part (Mohamed, 2012).

Najjar (1998) examined the use of animations and simulations among learners and found that when more visualized means are used, the better the learning process becomes. The study showed that the best method for teaching dynamic processes is through the use of computerized animation. Students who study using animations apply three learning styles: visual, auditory and kinesthetic. They use three senses; seeing, hearing and touching. Research shows that the usage of multi-senses for the construction of knowledge, promotes meaningful learning (Barak, et al., 2011). Animations used in this study give learners an opportunity to use their three senses and they promote meaningful learning to take place in Physics classrooms.

2.5 Multimedia Elements Used in Digital Educational Materials

Multimedia is a design with a combination of digital elements which are delivered on the same digital platform while providing a multidimensional, multi-sensory environment in which rich, efficient, instant, comprehensible, optimum and meaningful input and feedback can be presented to learners of all subjects at all stages of learning (Turel, 2014). Traditional educational
approaches result in a mismatch between what is taught to the learners and what the industry requires. As such, many institutions are moving towards problem-based learning as a solution to producing graduates who are creative; think critically and analytically, to solve problems since knowledge is no longer an end but a means to creating better problem solvers and to encourage lifelong learning (King, 2010).

Teo and Wong (2000) argue that problem-based learning is becoming increasingly popular in educational institutions as a tool to address the inadequacies of traditional teaching since the traditional approaches do not encourage learners to question what they have learned or to associate with previously acquired knowledge. Problem-based learning is seen as an innovative measure to encourage learners to learn how to learn via real-life problems (Boud and Feletti, 1999). The teacher uses multimedia to modify the contents of the material. When teachers use different multimedia elements in their teaching, learning becomes more meaningful. By incorporating digital media elements during the teaching and learning process, learners are able to learn better since they use multiple sensory modalities, which would make them more motivated to pay more attention to the information presented and retain the information for a longer time.

**Qualities of good educational animations**

Interactive digital content used in the E-learning environment has greatly increased in the last decade. According to Mohammed (2018) availability and increase of digital information necessitate availability of tools which help students and teaching staff members organize and integrate e-resources effectively in order to realize improvement on the learners’ performance. Online courses have continuously increased and as a result of this increase and complexity of
knowledge in various fields, many students who have self-organization of their studies in an E-learning environment often suffer from over-cognitive load. Moreover, they may feel confused while exploring, especially when studying according to resources-based learning strategy. Therefore, there is a dire need for instruments that can manage digital information in the educational contexts without tiring the learners with unnecessary and low quality content.

One of the tools used in educational content to make learning more permanent is animations. Heinch, M., Molenda, M., and Russell J. (1993) define education technology as a field of study which deals with the scientific knowledge about how people learn and application of the learned knowledge to solve real life problems while Reiser (1987) defines learning technology as using human and material resources to enable effective learning. Based on these definitions, education technology can be expressed as using tools in the teaching and learning process. Use of different learning materials in education activities provides for multiple learning environments which make it possible for teachers to meet individual needs of learners. These tools also motivate learners and make learning easier and permanent. One of the materials frequently used by teachers in teaching activities in teaching materials is animations. Musa, et al. (2013) notes that educational computer animation is one of the most elegant tools for presenting multimedia materials for learners, and its significance in helping to understand and remember information has greatly increased since the advent of powerful graphics-oriented computers.

Animation is a technology product that enables teaching subjects with visual and audio elements (Mayer & Moreno, 2002). Akaydm and Kaya (2018) define animation as showing pictures and graphics with motion. From these definitions, animations are the product of the process of
creating graphics which are in motion in a certain scenario. Using animations in education activities enables explaining abstract subjects in a more concrete way, developing representational process of individuals hence making learning fun, a more permanent activity, and offering a rich teaching resource for educators. Appropriate, suitable and on-time use of animation supports the learning process (Mayer & Moreno, 2002).

All aspects of interactive multimedia require the designers and developers to consider the requirements of cognitive load theory which puts emphasis on how essential it is to design every multimedia element effectively and efficiently (Turel, 2015). Efficiency and effectiveness of these elements is portrayed through their features. The following are some of the qualities of good educational animations:

i) **They should be interactive**

A good animation should give the learner an opportunity to interact with it. The learner should be in a position to play, pause, replay or stop the animation if need be. Replaying the animation may help the learner in getting some concepts which might have gone without getting noticed in the first playing of the animation. In some cases, animations may be used in comparing the effect of certain variables like in an experimental set up. The play buttons and control settings required to change these variables should be provided in the animation.
ii) They should make proper use of colour

Some objects have conventional colours and the same should be used when developing educational animations. For example, live wire should be illustrated using red or brown colour and this should be seen in the animations being developed in Physics materials.

iii) They should be in the correct proportions

The sizes of the objects being animated should not be over-exaggerated. The sizes used should be in the correct proportions with the real items. For example, if one is developing an animation with a fuse fitted in the live wire of a socket, the fuse may be illustrated as being reasonably smaller than the entire socket.

iv) They should assist the learner in understanding the text being learned

The main objective of using multimedia elements is to simplify abstract concepts in the subject matter being learned. In the process, they assist the learner in conceptualizing knowledge and retaining it for future use. The animations used in the content should therefore seek to assist the learner in understanding the abstract concepts which learners find difficult to understand. Animations should contribute to understanding of abstract concepts. According to Barak, et al. (2011), animation can contribute to a better understanding of the learning material in two ways if designed well. First, it enables the creation of mental representations of concepts, phenomenon and processes. Second, it can be used to support challenging cognitive processes such as abstraction, imagination, or creativity, which some learners are short of.

v) They should have properly synchronized sound if at all sound is embedded in them

The developed animations should have their text, graphics and sound in proper sync for learning to take place effectively. They should also be audible enough. The pace of
narrations should be appropriate for the level of the learner. Finally, the accent used should be familiar to the intended content user who in this case is the learner. Alty (2002) notes that when developing a presentation with voiceover and accompanying illustrations, it is important to be aware of the fact that the voice-over should still work well when presented as text-only.

It is however important for designers and developers of IDC to be aware of redundancy effect of multimedia learning. Results of cognitive load theory related research indicated that pictures and narration that are presented simultaneously with redundant on-screen text increase cognitive load and can impede learning due to the competition of resources in the visual working memory (Moreno and Mayer, 1999).

According to a study done by Seong, T., Waddah, S. and Wan Ahmad, W. (2010) whose purpose was to ascertain whether simultaneous static pictures and narration that are presented simultaneously with redundant synchronized on-screen text will generate the redundancy effect, or otherwise, in foreign language reading comprehension instruction, they note that there is need to establish when there is redundancy effect while using multimedia. The premise of the study was that, whereas in the case of native English speakers, English was a vehicle for the organization and control of instructional materials and activities, simultaneous static pictures and narration with redundant on-screen text is frequently detrimental to learning. However, this form of redundancy may have different effects when the goal is learning English as a foreign language rather than using the language to learn other content. Therefore, instead of increasing cognitive load due to redundancy, presenting information in both pictures and narration with redundant
synchronized on-screen text may facilitate the learning of English when instruction is directed to learning the language itself (Dio & Sweller, 2007).

However, it is important to note that presentation of words and corresponding pictures help students during the learning process. Mayer (2002) indicates that learners are more likely to engage in productive cognitive processing when corresponding words and pictures are presented at the same time. Simultaneous presentation increases the chances that corresponding words and pictures will be in working memory at the same time, thereby enabling the learner to construct mental connections between them. This cognitive processing results in deeper understanding as reflected in measures of problem-solving transfer. Simultaneous presentation results in deeper learning than successive presentation, therefore students learn more deeply from multimedia presentations in which animation and narration are presented simultaneously.

\textbf{vi) They should play at an appropriate pace}

The animations should play at a pace which learners using the materials can cope with.

\textbf{vii) They should have adequate navigational aids if the aids are needed}

In some cases, animations may need to have buttons for moving back and forth for instructional purposes and this should be provided for.

\textbf{viii) Logical sequencing of concepts presented}

Concepts, laws, theories and principles presented within the animations should be sequenced in a logical manner to enhance assimilation and accommodation of new knowledge being presented.

This study focused on the animations embedded in KICD interactive content for Form Three and its quality was rated against some of these qualities by the target Physics learners and teachers.
2.6 Policies on ICT Integration in Education

Integration of ICTs in education requires policy guidelines to give directions to the stakeholders involved in mainstreaming ICT in the teaching and learning process. In 2006, the Ministry of Education in Kenya developed a National ICT integration in education strategy. The strategy outlines how ICTs should be adopted and utilised to improve access, quality and equity in the delivery of education and training services in Kenya. Within the strategy, several areas for ICT integration are outlined which include establishment of policy framework, procurement of digital equipment, connectivity and network infrastructure, technical support, harnessing emerging technologies, digital content development, integration of ICTs in education, capacity building and professional development, research and development, partnerships and resource mobilization, legal framework, monitoring and evaluation.

The policy on ICT integration in education in Kenya is currently under development. Most of its components are already found in bits in several other national documents like the e-government strategy which was adopted in 2004, National ICT policy and Sessional paper No. 1 of 2005. The e-Government strategy emphasizes on using education to equip the nation with appropriate ICT competencies, skills and related competencies. In addition, the strategy has clearly outlined several systems in the education sector including Education Management Information System (EMIS) which will be used to collect and process data required for improvement of education policy, planning, implementation and monitoring. It also encompasses provision of online examinations, processing admissions for primary and secondary schools and online dissemination of educational curriculum support materials. EMIS has since evolved to become National Education Management Information System (NEMIS).
The National ICT policy’s main objective is to facilitate sustainable economic growth and development through use of productive and effective technologies. The policy envisages harnessing the potential of ICTs and related emerging technologies to reduce poverty, support universal basic education, improve maternal health among other goals. In human resource development, the policy emphasizes on integrating ICTs in teaching and learning at all level of education and training.

The Sessional Paper No. 1 of 2005 is a national policy framework for education, training and research. It emphasizes on the need to leverage on ICTs to ensure quality, equity and increased access to education across the country. In the three documents, the government is quite aware of the fact that ICT literate workforce is the foundation on which the nation will become a knowledge-based economy.

In view of these, there was need for a team to be constituted drawing its participants from the Ministry of Education and its agencies including Kenya Education Management Institute (KEMI), Teachers Service Commission (TSC), Centre for Mathematics, Science and Technology Education in Africa (CEMASTE), Kenya National Examinations Council (KNEC) and KICD to develop an ICT integration in education policy. The process of developing the policy is currently at an advanced stage but it has not been launched and its completion will give adequate guidelines on how technology should be utilised in the learning process for improved performance.

2.7 Chapter Conclusion

Several studies have been done in different places across the globe and they have shown that animations play a pivotal role in the learning process. Musa, et al. (2013) examined the
importance on animation and the study findings revealed that educational computer animation has become a very important tool for presenting multimedia materials to learners during the learning process. The study also found out that animations are key helping learners understand and remember the learned information. Findings of the study done by Gambari, et al. (2014) on the effect of computer animation and geometry instructional model on Mathematics achievement and retention revealed that learners who were taught using content with computer animations performed significantly better in post-test than their counterparts taught geometry using instructional model and traditional method respectively. Yigal (2009) studied the effects of an animation-based online learning environment on transfer of knowledge and on motivation for Science and technology learning. Adegbija & Falode (2014) conducted a study on the effect of animation-based camstudio Physics instruction on secondary school students’ performance in Minna, Nigeria. The findings of the study revealed that animation-based camstudio Physics instruction improves students’ achievement scores in Physics. Few studies have been done to establish the role played by animations in the learning of Physics in Kenya. This gap was identified and this study sought to establish the value animations add to the learning of Physics content.

Instruction in a Science classroom should ensure that learners are actively engaged in the material for maximum achievement of learning outcomes to take place (Swain, 2012). The incorporation of computer animations provides enhancement and relevance to Science learning. Rieber (1994) asserts that animations are new educational tools that foster long-term learning. Akpınar and Ergin (2008) point out that animations stimulate more than one sense at a time and therefore make learners more attentive during the learning process. These assertions are supported by some empirical studies. Srisawasdi and Panjaburee (2015) conducted a study on the
effect of simulation-based inquiry integrated with formative assessment on students’ conceptual learning of buoyancy-driven phenomena. The findings indicated that students’ understanding of buoyancy-driven concepts made continuous progress throughout the learning of the simulation – based inquiry coupled with formative assessment approach from pre-test to post-test and post-test to retention-test. This implies that use of simulation – based inquiry improves students’ conceptual understanding.

Jimoyiannis and Komis (2001) studied the effect of using computer animations on learners’ understanding of basic kinematics concepts concerning simple motions through the Earth’s gravitational field. The findings revealed that computer simulations led to an increase in learner’s content knowledge. The study recommended that computer animations can be used as a complement to other forms of instruction in order to facilitate learners’ understanding. Ummeh and Fawzia (2014) studied the effect of using computer animation in teaching Chemistry at Advanced level. These studies have been done in different subjects and in different parts of the world. In Kenya once again, very few studies have been done to establish the effect of animations on conceptual understanding of learners. Conduction of this study was therefore necessary to establish whether animations assist learners in terms of improving their conceptual understanding of the subject matter of a given discipline.

Studies conducted in different countries have shown that increasing students’ learning interests about Science and increasing their motivation level while learning very important aspects to be considered by any educator (Shu-Nu, et al., (2009). Computer-based simulations allow learners to work in an environment which facilitates their knowledge reformulation and concept attainment besides evoking and sustaining interest, concretizing learning and making learning less stressful (Wang and Reeves, 2007). Osborne, et al. (2003) did a study on interest of learners
and the learning activities they are engaged in and found out that the learning activities learners are engaged in affect concentration span of learners to a great extent. Wang and Reeves (2007) point out that one strategy used to enhance the active engagement of students as they learn Science is to design the computer – based animations with four intrinsic motivational strategies namely challenge, curiosity, control and fantasy. This increase their concentration span to a large extent. Olsen and Clough (2001) examined the effect of simulations on their capacity to grab and maintain their attention. It is worth noting that these studies have been done in different disciplines and in different countries. In Kenya, few studies have been done to establish the effect on animations on concentration span of learners and therefore the need to conduct this study.
3.0 Introduction

This chapter gives more details about how this study was conducted. Within the chapter, research design, variables in the study, location of the study, target population, sampling techniques, sample size, data collection instruments, pilot study, validity of the instruments, reliability of the instruments, ethical considerations, data collection during the study and ways used to analyse data have been discussed.

3.1 Research design

Various scholars describe research design differently. Kothari (2007) defines research design as the conceptual structure within which research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data. Orodho (2003) defines research design as the scheme outline or plan that is used to generate answers to research problems. Kombo and Tromp (2006) point out that a research design is an arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance with the research purpose. Kerlinger (1972) defines research design as the plan, structure and a strategy of investigation conceived so as to obtain answers to research questions and control variance.

Generally, decisions regarding what, where, how much, by what means concerning an inquiry or a study constitute a research design. It facilitates seamless execution of the various research operations, thereby making research as efficient as possible yielding maximal information with minimal expenditure of effort, time and money (Kothari, 2007).
A quasi-experimental research design was used in this study. This research design was used because during the study it was not possible to control all physical and human factors affecting performance of learners in Physics. It involved a pre-test and post-test experimental-control groups. In this design, Form Three classes from four (4) secondary schools were either in the Experimental Group (EG) which received the treatment, or Control Group (CG) which did not receive treatment. Figure 3.2 shows the quasi-experimental design used in this study;

<table>
<thead>
<tr>
<th>Experimental</th>
<th>R</th>
<th>O₁</th>
<th>X</th>
<th>O₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>R</td>
<td>O₂</td>
<td>X</td>
<td>O₄</td>
</tr>
</tbody>
</table>

**Figure 3.1: Illustration of research design for the study**

Where:  

- **R** = Randomization of both experimental and control groups
- **X** = Treatment for the experimental group: using animations.
- No treatment: not using animations.

- **O₁** = Pre-test for the experimental group
- **O₂** = Pre-test for the control group
- **O₃** = Post-test for the experimental group
- **O₄** = Post-test for the control group
Experimental and control groups were used where sets constituting both groups were picked from different secondary schools which are geographically far from each other such that the set making the EG was on the Western side of Nairobi County and the set constituting the CG was drawn from the Eastern side of the County. The distance between the location of the CG and EG schools was large enough in order to minimize the chances of interaction between the subjects in the two study groups. It is also worth noting that the EG and CG schools selected were of similar abilities and were equally equipped in terms of learning resources. Two (2) schools coded school C and D were used to provide learners for the CG while a set of the other two (2) schools coded school A and B provided learners who constituted the EG. According to Suleiman (2011) selecting the experimental and the control groups from different schools in different locations helps in controlling experimental treatment diffusion. The extraneous variables were controlled to some degree during this study. This was achieved through failure of the researcher to reveal the main areas of interest in the study to both groups. Figure 3.2 shows a summarized research process for this study.
Figure 3.2: Illustration of the research process
During the first phase of the study, a pre-test was given to both experimental and control groups. This was done to establish the level of content mastery of the learners before the treatment was given. Their scores were recorded and saved safely to be used later during the data analysis stage. After conducting the pre-test, the control group was presented with e-learning materials without animations to use for learning purposes and their performance measured by giving them a test similar to what they were given earlier. The test was marked and the scores were recorded. The EG was presented with learning materials with animations. The learners were given fourteen weeks to learn using IDC with animations and then their performance in the same topics was determined by administering the same test given to the CG during post-test activity. The test was marked and the scores were recorded. The topics selected for the study were the ones taught when data collection was ongoing and they included Newton’s Laws of motion and Refraction of light. This was done to ensure that there was compliance with the schemes of work drafted by the schools involved in the study.

3.2 Variables in the Study

In this research, there are three types of variables. These are the independent, intervening and the dependent variables. Fraenkel & Wallen (1993) argue that an independent variable is the variable which is chosen by the researcher in order to assess its possible effects on one or more other variables. Variables are the conditions or characteristics that the experimenter manipulates, controls, or observes. The independent variables are the ones that the experimenter manipulates or controls in an attempt to ascertain their relationship to observed phenomena. The dependent variables are the conditions or characteristics that experimenter introduces, removes, or changes independent variables (Best and Kahn, 2007).
In this study, the independent variables were the various Physics concepts in e-learning IDC, teacher ICT skills, teaching methods, teaching strategies, school support for use of ICT tools in teaching and motivation of the learners. The intervening variables were teachers’ and learners’ attitude, Physics teachers’ experience and school environment. The dependent variable is the variable being tested in a study. In this study, the dependent variable was performance of the learners in Physics.

3.3 Location of the Study

This study was done in four (4) secondary schools in Nairobi County drawn from two constituencies namely, Starehe constituency and Embakasi constituency. The two constituencies provided a representative case of many other constituencies in Nairobi County because they are among the ones whose schools were equipped with the necessary ICT infrastructure and equipment under the Economic Stimulus Programme and these were key in the study.

Also, the constituencies are conveniently located in Nairobi County in terms of accessibility and this factor led to increased efficiency during the data collection process. In addition to this, the researcher is also more familiar with the region. Efficiency during the data collection process was increased since familiarity of the researcher led to increased efficiency in administration of instruments and monitoring of how the learners were utilising IDC. Use of two constituencies instead of four constituencies also contributed a lot in making the study efficient since administration of data collection tools and monitoring the instructional process during the study was done with ease and minimum time was used. Kombo and Tromp (2006) indicate that the selection of a research site is essential as it influences the usefulness of the information produced and this was experienced during the data collection process.
The sampled secondary schools were coded as school A, school B, school C and school D in this study. The four schools were purposively sampled because they benefited from the Economic Stimulus Programme where they were supplied with desktop computers, printers and LCD projectors. These ICT equipment were necessary for the success of this study. School A and school B were selected from the western side of Nairobi County. School C and school D were selected from the eastern side of Nairobi County. School A and school B were the experimental schools while School C and school D were the control schools.

3.4 Target Population

The target population was forty (40) ESP schools in Nairobi County. Best and Kahn (2007) define population as any group of individuals that have one or more characteristics in common and that are of interest to the researcher. The population may include all the individuals of a particular type or a more restricted group. Population here refers to the larger group from which the sample is taken. This study targeted Form Three Physics learners and teachers in public secondary schools in Nairobi County. Form Three Physics learners were preferred because at this level, they had already selected Physics and were familiar with the computing devices. Dealing with Form Three learners who have already selected the subject assisted in controlling the extraneous variables like learner’s attitude and interest. Form Four learners were not considered for this study because they were busy preparing for their Kenya Certificate of Secondary Education (KCSE) examinations. Form One learners were relatively new in the school and were still in the process of familiarizing themselves with the school environment and curriculum activities. Form Two learners were also not considered for this study because they had not yet selected the subjects to study. Selecting Form Two learners
would make it difficult to control some of the extraneous variables that might have affected this study.

The four schools selected benefited from the Economic Stimulus Programme and were given the essential ICT infrastructure and ICT devices to enable them integrate ICT in the teaching and learning process. In terms of resources, the sampled schools were equally equipped. Learners in the sampled schools were also of similar abilities. These schools were considered as appropriate for this study since utilisation of IDC required digital devices and electrical power. Teachers in these schools had also been trained on how to prepare ICT integrated schemes of work and teach using ICT integrated lesson plans.

3.5 Sampling Techniques

Sampling is taking any portion of a population or universe as representative of that population or universe (Kerlinger, 1972). It involves selection of a smaller group of participants to inform essentially about what a larger population might tell us if we asked every member of the larger population the same questions. It refers to the method used for selecting a given number of people or subjects from a population. When a sampling process is successfully conducted, it yields a sample.

Sample refers to a group chosen from a larger population with the aim of yielding information about the population. The need to draw inferences about a large population from a subset of that population was the main concern during this study. There was therefore need to ascertain that the sample truly represents the population. Use of effective sampling
procedures while selecting the research sample gave way for the research results to be used to make generalizations about the entire population.

In Nairobi County, each of the eight constituencies had benefitted from the ESP programme. In every constituency, five schools had benefitted by getting computers, LCD projectors and printers among other ICT equipment. Simple random sampling was used to select two constituencies from Nairobi County. Pandey (2005) defines simple random sampling method as a method where all members or units of the population have an equal and independent chance of being included. It also implies that the inclusion of a particular unit in one draw has no influence on the probabilities of inclusion in any other draw.

Out of the two constituencies selected, purposive sampling was used to select schools which benefitted from the Economic Stimulus Programme (ESP) in every constituency. Purposive sampling was used because the study required schools with ICT equipment and these resources were only found in the ESP schools. Simple random sampling was done to obtain the sample schools. In Quasi – experimental design, a smaller sample is used. In this study, two groups namely the EG and CG were used. The two groups were of similar abilities and were equally equipped in terms of resources.

3.6 Sample Size

In the course of this study, individual schools were sampled. According to Kothari (2007) sample size refers to the number of items to be selected from the universe to constitute a sample. The size of the sample should neither be exclusively large nor too small, it should be optimum. During this study, two ESP secondary schools were selected from two randomly selected constituencies in Nairobi County. To select the four ESP schools to be used as the sample
schools for this study, simple random sampling was used. This gave a total of four (4) secondary schools from the county and 104 Form Three Physics learners. Among the four sampled schools, two schools were girl schools and the other two were mixed schools. The experimental schools had a total of fifty eight (58) students while the control group had forty six (46) learners. The experimental group comprised of thirty eight (38) girls and twenty (20) boys. The control group comprised of nineteen (19) girls and twenty seven (27) boys. The total number of students in the four schools was one hundred and four (104) and this constituted sample size for the study. Table 3.1 shows the sampling grid for this study.

Table 3.1: Sampling Grid for the Study

<table>
<thead>
<tr>
<th>No. of constituencies in Nairobi County</th>
<th>No. of secondary schools in Nairobi County</th>
<th>No. of constituencies in the sample for this study</th>
<th>Total No. of ESP secondary schools in Nairobi County</th>
<th>No. of Physics students involved in the sample for the study</th>
<th>No. of Physics teachers involved in the sample for the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>60</td>
<td>2</td>
<td>40</td>
<td>104</td>
<td>4</td>
</tr>
</tbody>
</table>


3.7 Data Collection Instruments

Physics teachers and learners from both control and experimental schools were oriented on how to utilise Physics IDC at the beginning of the study. To determine the instructional role played by the animations in enhancing conceptual understanding of the content and the effect on student performance, tests (pre – test and a post – test) were given to the learners in the course of the study. These tests were administered to one hundred and four (104) Form Three learners from the sampled schools. The experimental group had fifty eight (58) subjects out of which, thirty
eight (38) were girls and twenty (20) were boys. On the other hand, the control group had forty six (46) subjects among which nineteen (19) were girls and twenty seven (27) were boys. Before administering the treatment, a pre - test was given to both the control and experimental group. The role of this pre-test was to determine content mastery of the subjects within the experimental and control groups on the topical areas under study. The experimental group was given the treatment which in this case was IDC with animations. The control group was given IDC without animations for learning purposes. After interacting with these materials from the month of September to December 2017, a post - test was administered to the two groups. The tests were marked to determine the performance of the learners in the topics of interest in this study. Learners’ scores were recorded for use during data analysis.

Physics teachers in the experimental schools were given a questionnaire to fill in order to determine how relevant each animation was to the text it was attached to among other attributes such as the level of interactivity of the animations and the ability of the animations to simplify abstract concepts. The teachers involved in the study had a teaching experience of more than ten years and were able to determine whether the animations were relevant, interactive and also whether they were able to simplify abstract concepts. All animations embedded in the content were serialized for ease of identification. Ratings on the relevance of animations were done by use of a five – pointer Likert scale and the data collected was analysed to determine whether the animations were relevant or not. An Observation Schedule (OS) was also designed and it assisted in observing and gauging the learners’ concentration span while using IDC. Table 3.2 is a matrix which displays objectives of the study, type of instrument(s) used to collect data and the type data collected.
<table>
<thead>
<tr>
<th>Objective</th>
<th>Type of instrument used to collect data</th>
<th>Type of data collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>To determine the influence of instructional values inculcated by animations on learners’ performance in Physics</td>
<td>• Use of an observation tool and questionnaires</td>
<td>• Qualitative and quantitative data</td>
</tr>
<tr>
<td>To determine the effect of animations on the concentration span of learners while learning Physics.</td>
<td>• Use of an observation tool and questionnaires</td>
<td>• Qualitative and quantitative data</td>
</tr>
<tr>
<td>To find out if animations enhance conceptual understanding of text within the Physics IDC.</td>
<td>• Use of Pre &amp; Post tests given to subjects • Means &amp; T - test used during analysis • Use of teachers’ and learners’ questionnaires.</td>
<td>• Quantitative and qualitative data</td>
</tr>
</tbody>
</table>
3.8 Pilot Study

A pilot study was conducted in two schools within Nairobi County and it is worth noting that these two schools were excluded in the main study. The main reason of piloting was to determine validity and reliability of the data collection instruments. Piloting the tools to check on these two aspects was important in that it assisted in knowing whether the tools were suitable and appropriate. After piloting, several gaps in the instruments were identified and the necessary corrections and modifications were done to ensure that the instruments were valid and reliable.

3.9 Validity of the Instruments

One of the reasons of doing piloting was to ensure content validity of the data collection instruments. Five Physics teachers with a minimum teaching experience of ten years and who are Kenya National Examinations Council (KNEC) examiners in Physics were exposed to the test (pre –test and post- test) items and their views were taken into consideration while validating the instruments to ensure that they measured what they are supposed to measure. The five teachers used to validate the pre – test and post – test items were neither picked from the two schools used for piloting purposes nor from the schools sampled for this study.

3.10 Reliability of the Instruments

The researcher established the reliability ($r_{tt}$) of the instruments before using them to collect data during the main study. Hatch & Farhady (1982) state that reliability is the extent to which a research tool produces consistent results when administered under similar conditions. Reliability is defined as the consistency of the obtained scores. It shows how consistent the scores for each individual from one administration of an instrument to another and from one set of items to another.
Reliability is always dependent on the context in which an instrument is used. Depending on the context, an instrument may or may not submit reliable responses. When the data collected is unreliable, it cannot be used to make valid inferences. Reliability of the questionnaires was determined using the test - retest method and they were adjusted slightly after piloting to make them fully reliable using the Cronbach’s Alpha which gave a value of 0.75.

Reliability of the Observation Schedule (OS) was established by use of the two Physics teachers who were teaching in the pilot schools. They were first trained on how to use the observation tools and later on they were requested to use the tool with the learners. Their observations were reported in terms of agreement between their results after conducting observations in both schools. The following formula was used to calculate their level of agreement.

\[
\frac{\text{Number of agreements}}{\text{Number of agreements} + \text{Number of disagreements}}
\]

The two trained teachers who were used as independent observers were able to achieve an 83% overall percentage of agreement. Ragosta (1974) states that a mean percentage of 86.8% for variables least frequently recorded and 69.0% for variables most frequently reported based on different observations done by observers on different locations is acceptable.

3.11 Ethical Considerations

The researcher sought approval to conduct the study firstly from Kenyatta University Graduate School. After approval of the research proposal by the Graduate School of Kenyatta University, a research permit was sought from the National Commission for Science, Technology and
Innovation (NACOSTI). Permission to use the Form Three Physics IDC for the purpose of this study was also sought from KICD administrators. The Nairobi County administrators were visited and they granted permission for this study to be conducted in the sampled schools. Lastly, principals of the sampled schools were visited and they granted permission for the required data to be collected. Teachers and learners gave consent for photographs to be taken, audio and video recordings to be done during the data collection process.

3.12 Data Collection and Analysis

The process of data collection was not devoid of challenges. The researcher sought for a permit to collect data in Nairobi County from NACOSTI and this was granted in July 2017. The next step was to collect data from the sampled schools. At this time, schools were just about to break for August holidays hence it was not possible to collect data at this time. The entire activity was postponed to third school term of the year 2017. In third term, the researcher visited the sampled schools one at a time training the targeted teachers on how to effectively teach using IDC. Learners were shown how to utilize Physics content within the digital versatile disk. This was combined with issuance of the content to the teachers and learners. This basically took place during the month of September 2017.

It was not possible to carry on with the study as intended because the Kenya Certificate of Secondary Education (KCSE) examinations kicked off later in the month of October and the learners had not interacted with IDC for learning purposes adequately. This led to extension of the period of using the content for learning purposes and learners were allowed to continue using the digital content. The sampled schools were visited before schools closed for December holidays and learners were encouraged to continue using the interactive digital content. This
extended the period of data gathering further and the researcher was forced to continue with the research during the first term of 2018. By then, the targeted learners had also been promoted to Form Four.

After facing these challenges, finally the process of data collection began. During data collection process, teachers were trained on how to use the materials with Physics IDC. Their training included loading, unloading and navigating through the resource with the Physics content. Learners were shown how to navigate through the learning resource with Physics IDC after loading it on the computers. This enabled the target respondents to be able to navigate the entire material without leaving out any content. This activity was carried out in all schools.

The developed instruments were administered to the respondents and the data collected was processed and stored in a spreadsheet. The data collected was analyzed using means and frequency distributions. In addition to this, t-test was also used to analyse data. It was computed and used to determine whether the difference in the means posted by learners while using content with and without animations in the selected topics was significant or not. The OS was filled by the researcher when teachers and learners were using Physics IDC for teaching and learning purposes. The Physics teachers’ questionnaires and learners’ questionnaires were administered after doing the post-test. The sampled Physics teachers and learners filled the questionnaires and later on, the researcher collected them and processed the data collected. The Statistical Package for the Social Sciences (SPSS) version 18 was used to analyse the collected data. The analysed data is presented in tables, graphs and pie-charts. The findings from this study were reported, conclusions drawn and recommendations made based on the findings.
CHAPTER FOUR: DATA PRESENTATION, INTERPRETATION AND DISCUSSION

4.0 Introduction

The overarching goal of this study was to determine the effect of animations in e-learning materials on secondary school learners’ performance in Physics. This chapter has dealt with data presentation, interpretation and discussion. An instructional model for teaching using ICTs has also been developed towards the end of the chapter.

4.1 Findings

During this study, both quantitative and qualitative data was collected. Quantitative data has been analysed under several headings as seen in the paragraphs which follow. Qualitative data was cleaned up and organised in terms of themes. Key excerpts from the respondents’ responses have been used to compliment the quantitative data. Analysis of data was done following the objectives of the study. The results from the analysed data were used to test whether the null hypotheses made are valid or not and retention or rejection of the null hypothesis was done where applicable based on the findings of the study.

4.1.1 General and Demographic information

This section presents general information of the different respondent categories. The study was conducted in four (4) secondary schools in Nairobi County namely, School A, School B, School C and School D. Data was collected from learners and teachers in the four secondary schools. Learners from the four schools were given different codes during data processing. Learners from School A were given codes from N001 to N026. Learner respondents from School B were coded from T001 to T032. Learners from School C were given codes from R001 to R004 and likewise,
learners from School D were coded from J001 - J042. School A and School B formed the sample for the Experimental Group (EG). Learners from School C and School D formed the sample for the Control Group (CG). The EG had a total of fifty eight learners while CG had forty six learners. Figure 4.1 is a graph showing the number of subjects from each school and their proportions in terms of sex in percentages.

**Figure 4.1 Proportions of Physics Learners used in the Study**

The total number of learners used in the study were one hundred and four (104). Learners from School A were twenty six, School B had thirty two, School C had four and School D had forty two Physics learners. Figure 4.2 gives the proportions of learners used in the study from each school in terms of numbers and the corresponding percentages.
In total, the number of boys involved in the study were forty seven (47) and the number of girls involved were fifty seven (57). Figure 4.3 shows the proportion of learner respondents by sex in terms of numbers and corresponding percentages.
Four Physics teachers were involved in this study. Out of the four, only one was female. Figure 4.4 shows the proportions of teachers used in terms of gender. Their proportions are presented in numbers and percentages.

![Proportion of Teachers in terms of Sex](image)

**Figure 4.4: Proportion of Teachers in terms of Sex**

4.1.2 **Instructional Values inculcated by Animations Embedded in IDC**

The first objective of this study was to determine the influence of instructional values inculcated by animations embedded in Interactive Digital Content (IDC) on the performance of learners in Physics. Instructional values affect the way learning takes place. They affect the way teachers teach and the expectations they have from their learners. They also affect what teachers expect from learners during the instructional process. The instructional values include interest and motivation levels of teachers and learners. In this study, the main focus was on the instructional values of learners. Ramma, *et al.* (2018) assert that academic lives of our learners are often reflected through challenging and complex interactions of the cognitive, affective and behavioural aspects, such as beliefs, values, interest, motivation, engagement and persistence.
towards learning and performance. Interest is an excitement or feeling accompanied by special attention to do something. When learners are motivated and interested in the learning process, they perform better. To establish the influence of the instructional values inculcated by animations embedded in IDC on performance of learners in Physics, questionnaires were administered to both learners and teachers. An Observation Schedule (OS) was also used to gather additional information about the instructional values inculcated by animations embedded in Physics IDC during the instructional process. The questionnaires had some statements which both Physics teachers and learners responded to in order to determine the influence of instructional values inculcated by animations in IDC on learners’ performance in Physics. The OS also had some guiding statements in its criteria which assisted in establishing the instructional value of animations.

Teachers and learners responded to some items in the questionnaire which sought to establish whether the Physics IDC had the capacity to inculcate instructional values among Physics teachers and learners. Some of the attributes which assisted in determining this include ability of the content to arouse the learner’s interest, ability of the content to motivate learners to read more and ability to make learning fun. Learners were supposed to respond to statements which sought to establish the instructional values inculcated by animations embedded on IDC. The five-pointer scale had the scales of: Strongly Agree (SA); Agree (A); Not Sure (NS); Disagree (D) and Strongly Disagree (SD).

Tables 4.1a and 4.1b show the learners’ responses on statements meant to establish the ability of IDC to inculcate instructional values during the instructional process.
Table 4.1a: CG Learners’ Responses on Instructional Values Inculcated by Animations

<table>
<thead>
<tr>
<th></th>
<th>Control schools</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA f</td>
<td>%</td>
<td>A F</td>
<td>%</td>
<td>NS f</td>
<td>%</td>
</tr>
<tr>
<td>Content more interesting</td>
<td>23</td>
<td>50.0</td>
<td>22</td>
<td>47.8</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>Content motivates one to read more</td>
<td>18</td>
<td>39.1</td>
<td>21</td>
<td>45.7</td>
<td>4</td>
<td>8.7</td>
</tr>
<tr>
<td>Makes learning more fun</td>
<td>29</td>
<td>63.0</td>
<td>14</td>
<td>30.4</td>
<td>1</td>
<td>2.2</td>
</tr>
</tbody>
</table>

From Table 4.1a, 50% of learners in the control schools strongly agreed that the content is interesting while 47.8% agreed to the same statement. It was also revealed that 39.1% of learners strongly agreed that the content motivates them to read more. Only 2 (4.3%) of learners disagreed with the fact that the IDC motivates one to read more.

On the issue of the ability of the content to make learning fun, 63% of the learners strongly agreed that the content makes learning fun while 30.4% agreed to the same statement. Only 2 (4.3%) disagreed with this statement. It is worth noting that the content given to learners in the control group did not have animations but they still found it interesting. This implies that if they interacted with the content with animations, they would be in total agreement that the content makes them more interested and motivated to read more.

Table 4.1b gives the responses of learners from the Experimental Group (EG) on the ability of IDC with animations to inculcate instructional values among learners.
Table 4.1b: EG Learners’ Responses on Instructional Values Inculcated by Animations

<table>
<thead>
<tr>
<th></th>
<th>Experimental schools</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
<td>A</td>
<td>NS</td>
<td>D</td>
<td>SD</td>
</tr>
<tr>
<td>Content more interesting</td>
<td>20 35.7</td>
<td>27 48.2</td>
<td>9 16.1</td>
<td>0 0.0</td>
<td>0 0.0</td>
</tr>
<tr>
<td>Content motivates one to read more</td>
<td>23 41.1</td>
<td>25 44.6</td>
<td>4 7.1</td>
<td>2 3.6</td>
<td>2 3.6</td>
</tr>
<tr>
<td>Makes learning fun</td>
<td>19 33.9</td>
<td>27 48.2</td>
<td>8 14.3</td>
<td>2 3.6</td>
<td>0 0.0</td>
</tr>
</tbody>
</table>

From Table 4.1b, the responses of learners in the experimental schools are displayed. The findings show that 35.7% of learners in the experimental schools strongly agreed that the content is interesting while 48.2% agreed to the same statement. It was also revealed that 41.1 % of learners strongly agreed that the content motivates them to read more and 44.6% agreed to the same statement. On the issue of the ability of the content to make learning fun, 33.9% of the learners strongly agreed that the content makes learning fun while 48.2% agreed to the same statement. Only 2 (3.6%) disagreed with this statement.

From the Tables 4.1a and 4.1b, it is evident that the learners from both categories of schools rated the content highly in terms of being interesting to them while learning. From Table 4.1b, 83.9% of the learners who responded to the questionnaire from EG were in agreement that the IDC is interesting. When the content is interesting, learners are likely to spend more time with it as learning takes place. They concentrate on it for longer and they enjoy more as they learn. This fact is confirmed by other related statements which were put in the questionnaire to elicit responses which were meant to establish whether the IDC could help in inculcating instructional values among learners. One of the statement related very closely to this is the ability of the content to motivate learners to use it. It was found out that 85.7% of the learners responded to the affirmative that the content motivates them to read more.
When one is motivated, they are most likely to use the content for longer and hence perform better. Use of IDC with animations can help in changing this situation.

**Teachers’ Responses on Ability of IDC to Inculcate Instructional Values**

It was indicated earlier that the quality of IDC affects performance of learners. Physics teachers teaching in the EG schools gave their ratings on some statements which sought to determine the influence of instructional values inculcated by animations on learners’ performance in Physics. A questionnaire was administered for them to fill. Data was collected and analysed out of their responses and it was found out that 50% of teachers strongly agreed with the statement that the IDC was interesting while 50% agreed that it is interesting. On the other hand, 100% of teachers who responded indicated that the IDC was motivating to the learner. In addition to this, 100% of teachers agreed to the fact that the IDC makes learning fun.

The teachers’ questionnaire had attributes which sought to establish the quality of the interactive content and specifically animations. In most cases, animations are meant to make concepts less abstract for learners to understand with much ease. Teachers generally rated the content highly in terms of its ability to motivate learners. They found it interesting and having the ability to engage learners for longer periods. Teachers agreed and strongly agreed to statements like the content having the capability of making learning fun, motivating to the learner and making learning interesting. The positive responses which teachers gave to these statements show that the IDC is rich enough and has the capability of inculcating instructional values in Physics teachers and learners.
During data collection, an Observation Schedule (OS) was used to guide on collecting data pertaining to level how learners were interested and motivated while using IDC. Several attributes meant to establish how the content was able to extend the concentration span of the learners were included in the observation schedule and observations were made recorded. The results of the analysed data are as presented in the Tables 4.2a and 4.2b.

Table 4.2a: Data about Instructional Values from OS for CG

<table>
<thead>
<tr>
<th>Observation points</th>
<th>Control Schools (N = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
</tr>
<tr>
<td>Learners interacted with IDC</td>
<td>0</td>
</tr>
<tr>
<td>Learners remained attentive throughout while using IDC</td>
<td>0</td>
</tr>
<tr>
<td>Learners appeared interested while using IDC</td>
<td>0</td>
</tr>
</tbody>
</table>

From Table 4.2a, it is seen that 50% of the learners from the control schools were interacting with the content in a fairly adequate manner while the rest 50% were adequately interacting with it. Regarding the issue of learners’ interest while using IDC, the observations made show that learners found IDC fairly interesting.
### Table 4.2b: Data on Instructional Values from OS for EG

<table>
<thead>
<tr>
<th>Observation points</th>
<th>Experimental Schools (N = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
</tr>
<tr>
<td></td>
<td>Count %</td>
</tr>
<tr>
<td>Learners interacted with IDC</td>
<td>0 0 0 0 0 1 50 1 50</td>
</tr>
<tr>
<td>Learners remained attentive throughout while using IDC</td>
<td>0 0 0 0 0 1 50 1 50</td>
</tr>
<tr>
<td>Learners appeared interested while using IDC</td>
<td>0 0 0 0 0 0 0 0 2 100</td>
</tr>
</tbody>
</table>

Table 4.2b presents the results from the observations made in the experimental schools. It is seen that more than 50% of the learners were interacting with the content adequately. In all experimental schools, learners were using IDC in a meaningful manner. Regarding the issue of learners’ interest while using IDC, 100% of the learners in the experimental schools were interested in learning while using IDC.

The OS assisted in making observations on whether the learners were interacting with IDC or not. The Likert scale assisted in establishing the level at which they were interacting with IDC. Other attributes of the content which the observation schedule sought to find out are the level of learners’ interest while using the content and ability of learners to make the expected correct observations and conclusions.
On the stated aspects, it was evident that learners in the control schools did not engage meaningfully with the IDC while on the other hand, their counterparts in the experimental schools did better. Learners in the experimental schools were very interested in learning. Quality animations engage the learner and elicit a lot of interest among learners during the learning process. Learners from the experimental group made positive comments about IDC in terms of making them interested in studying Physics. This is an excerpt from the comments made by one of the learners from the experimental group:

“The Physics interactive digital content has been a great stuff especially to some of us (students) who were serious with the content. It has brought a positive change and to add a suggestion if concerned staff could add even form four content it would be a good act.” (EXP-ND-L-N005)

Another learner from the EG stated “The Physics content encourages computer reading classes for it is more educative than textbook to be only for revision for they are also boring compared to CDs I have used to learn Physics” (EXP-ND-L-N003). Another learner from EG stated “Learning is enjoyable with this kind of content. I can learn a lot from it. Teachers can also use it to teach us but we also need more computers in our school to avoid sharing the computers” (EXP-T-L-T024).

On the other hand, learners in the control schools were given content which did not have animations. Their level of interest was lower compared with their counterparts in the experimental schools. They did not pay a lot of attention to the content they were using and hence they were not able to engage with their teacher meaningfully. A learner from one of the
control schools had this to say “Me think songs can be included there because songs are more attractive than watching.” (CTR-JEH-L-J027). This statement implies that the learner was not fully interested in using this content.

Quality IDC with all multimedia elements is interesting and motivates learners to use the resource with IDC for a longer period. From these findings, it was found out that the content was able to motivate learners and sustain their interest during the learning process. This leads to better performance in Physics. Several studies have shown that it is important to increase the learner’s interest as they learn Science. This leads to better performance in Science. Furthermore, learner’s attitude and motivation should be considered as an essential indicator of the quality of Science education (Shu-Nu, et al., 2009). According to Ramsden (1998), young people have generally held unfavorable attitudes and beliefs towards Science. Osborne, et al. (2003) confirmed this finding through a comprehensive review of literature from the past twenty years and its implications. It was concluded that to remediate the continuing decline in the number of learners pursuing further studies in Science, teachers need to reflect on their teaching and learning activities so that learners’ motivation and engagement in Science-related activities can be increased. Use of IDC with animations can help in changing this situation in learning.

In order to understand learners attitudes towards Science, their motivation levels in science has to be examined. Barak, et al. (2011) sought to investigate not only the effect of animated movies on learners’ learning outcomes, but also the effect of animated movies on learner’s motivation to learn. The authors investigated the use of web-based animated movies into the Science curriculum of 4th and 5th grade pupils. The findings of this study indicated that use of animated movies promoted students’ explanation ability and their understanding of scientific concepts. The findings of the study also indicated that learners who studied Science with the
use of animated movies developed higher motivation to learn Science. These learners developed higher motivation in terms of: self-efficacy, interest and enjoyment, connection to daily life and importance to their future, compared to learners in the control group. While carrying out the learning assignments and participating in class discussions, the learners were engaged in organizing the newly introduced scientific concepts and integrating them into a coherent structure of knowledge. In the study by Barak, et al. (2011) the EG learners showed significantly higher motivation in all categories, compared to the CG learners. The authors suggested that the use of BrainPop animated movies enhances students’ motivation to learn Science, compared to just using textbooks and still-pictures.

Extensive research has also shown a correlation between positive student perceptions and performance. The findings of this study agree with those of a study conducted by Rigby, Deci, Patrick and Ryan (1992) which found out that there is a strong relationship between motivation and learning achievement. When learners are more engaged in learning, they conceptualise and fully understand new knowledge and are more flexible while applying it in real life situations. By promoting intrinsic motivation of learners, task involvement will increase and consequently, performance will be better. The use of animations on Physics subject makes learning more enjoyable and does not make learners bored in monotonous learning (Rutten, et al., 2012). Findings from this study have revealed that animations elicit a lot of interest among students during the learning process.

4.2.2 Effect of Animations on the Concentration Span of Learners

The second objective of this study was to determine the effect of animations on the concentration span of learners while learning Physics. Teachers and learners responded to some items in the questionnaire which sought to establish whether Physics Interactive Digital Content (IDC) had
the capability of increasing the concentration span of the learners. Several statements were deliberately developed within the questionnaire to establish whether the animations had the capability of extending the learners’ concentration span. Some of the attributes which assisted in determining this include ability of the content to arouse the learner’s interest, ability of the content to motivate learners to read more, ability of the content to extend the learner’s concentration span, ability to make learning more fun and the ability of the content to engage the learner fully. Tables 4.3a and 4.3b show the learners’ responses on statements meant to establish the ability of the content to extend the learner’s concentration span.

Table 4.3a: Ability of IDC without Animations to Extend Learner’s Concentration Span

<table>
<thead>
<tr>
<th>Control schools</th>
<th>SA</th>
<th>A</th>
<th>NS</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDC extends one’s concentration span</td>
<td>16</td>
<td>35.6</td>
<td>17</td>
<td>37.8</td>
<td>9</td>
</tr>
<tr>
<td>IDC engages learners fully</td>
<td>20</td>
<td>43.5</td>
<td>13</td>
<td>28.3</td>
<td>7</td>
</tr>
</tbody>
</table>

From Table 4.3a, 35.6% of learners in the CG strongly agreed that IDC helps them to concentrate for a longer period while 37.8% of the learners agreed to this statement. Only 2 (4.4%) of learners disagreed with the fact that it extends their concentration span. It was also found out that 43.5% of the learners strongly agreed with the fact that the content engages them fully. 28.3% agreed with this statement and 15.2% of learners were not sure. It is worth noting that the content given to learners in the CG did not have animations but they still found it interesting. This implies that if they interacted with IDC with animations, they would be in total agreement that the content can extend their concentration span. Table 4.3b gives the responses of learners from the EG on the ability of the content to extend the concentration span of learners. The five-
The pointer scale used in the questionnaires had the scales of: Strongly Agree (SA); Agree (A); Not Sure (NS); Disagree (D) and Strongly Disagree (SD).

**Table 4.3b: Ability of IDC with Animations to Extend Learner’s Concentration Span.**

<table>
<thead>
<tr>
<th></th>
<th>Experimental schools</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
<td>A</td>
<td>NS</td>
<td>D</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>IDC extends one’s concentration span</td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>IDC engages learners fully</td>
<td>20</td>
<td>35.7</td>
<td>21</td>
<td>37.5</td>
<td>7</td>
<td>12.5</td>
</tr>
<tr>
<td>IDC engages learners fully</td>
<td>15</td>
<td>26.8</td>
<td>28</td>
<td>50.0</td>
<td>9</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Table 4.3b, displays frequencies and percentages of learners’ responses from experimental schools on the ability of IDC with animations to engage and extend learners’ concentration span. It was found out 35.7% of learners in the experimental study group strongly agreed that IDC helps them to concentrate for a longer period while 37.5% of the learners agreed to this statement. On the issue of IDC engaging learners fully, 50% of the learners agreed with this statement while 26.8% of the learners strongly agreed with the same statement.

From Tables 4.3a and 4.3b, it is evident that learners from both study groups rated IDC highly in terms of its ability to engage and extend learners’ concentration span. Learners were given a direct statement which sought to establish whether IDC extended their concentration span and 73.2% of learners agreed to this. Another statement which was closely related to extension of concentration span was the ability of IDC to engage learners fully. On this statement, the level of agreement (76.8%) which learners expressed in these statements implies that IDC had a high chance of extending their concentration span.
Teachers’ Responses on Ability of IDC to Extend Learners’ Concentration Span

The quality of IDC and specifically animations affects performance of learners in a subject. Physics teachers rated the quality of IDC presented to their learners on several aspects and the findings are presented in Table 4.4.

### Table 4.4: Quality of Physics IDC as rated by Physics Teachers

<table>
<thead>
<tr>
<th>Quality of interactive digital content</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Not sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDC extends the learners’ concentration span</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IDC engages learners fully</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The findings of the study revealed that 100% of teachers agreed with the statement that IDC extends the learner’s concentration span. It was also found out that 50% of teachers indicated that IDC with animations engages learners fully. The teachers’ questionnaire had attributes which sought to establish the quality of IDC and specifically animations. Physics teachers found IDC interesting and having the ability to extend the learner’s concentration span. This was confirmed by statements which sought to establish the ability of the content to extend the learners’ concentration span. Teachers agreed and strongly agreed to statements like the content engaging learners fully, motivating to the learner and making learning interesting. The positive responses which teachers gave to these statements show that IDC is rich enough and has the capability of extending the learner’s concentration span.

### Ability of IDC to Extent Concentration Span of Physics Learners

During the study an OS was used and its main objective was to observe the way learners were using IDC while learning. Several attributes meant to establish how the content was able to...
extend the concentration span of the learners were included in the observation schedule and observations were made during the data collection period. The observation schedule assisted in establishing the level of attentiveness of the learners while using IDC, level at which learners were interacting with IDC, ability of learners to make the expected correct observations and conclusions.

The results of the analysed data are as presented in the Tables 4.5a and 4.5b.

**Table 4.5a: Data Collected using OS from Control Schools**

<table>
<thead>
<tr>
<th>Observation points</th>
<th>Control Schools (N = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
</tr>
<tr>
<td>Learners interacted with IDC</td>
<td>0 0 0 0 1 50 1 50 0 0</td>
</tr>
<tr>
<td>Learners remained attentive throughout while using IDC</td>
<td>0 0 1 50 0 0 1 50 0 0</td>
</tr>
</tbody>
</table>

From Table 4.5a, it is seen that 50% of the learners from the control schools were interacting with the IDC without animations in a fairly adequate manner while the rest 50% were adequately interacting with it. In the CG schools still, the level of learners’ attention while using IDC was not high.
Table 4.5b: Data Collected using OS from Experimental Schools

<table>
<thead>
<tr>
<th>Observation points</th>
<th>Count</th>
<th>%</th>
<th>Row N</th>
<th>%</th>
<th>Count</th>
<th>%</th>
<th>Row N</th>
<th>%</th>
<th>Count</th>
<th>%</th>
<th>Row N</th>
<th>%</th>
<th>Count</th>
<th>%</th>
<th>Row N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners interacted with IDC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>1</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners remained attentive throughout while using IDC</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>1</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5b presents the results from the observations made in the experimental schools. In all EG schools, learners’ attention while using IDC was considerably higher compared to learners’ attention in the control schools. Regarding the issue of learners’ attentiveness while using IDC, 100% of the learners in the experimental schools were found to be very attentive while using IDC.

On the stated aspects, it was evident that learners in the control schools did not engage meaningfully with IDC while on the other hand, their counterparts in the experimental schools did better. Learners in the experimental schools were more attentive while using IDC and were highly motivated. Quality animations engage the learner and elicit a lot of interest among learners. Learners concentrate for longer while using IDC with animations and they are able to spend more meaningful Academic Learning Time (ALT) while interacting with it.
On the other hand, learners in the control schools were given content which did not have animations. Their level of attention while using IDC was lower hence they were not able to engage fully with IDC during the learning process. Quality IDC with animations helps learners to concentrate for longer and they end up using IDC in a meaningful way for a longer period. From these findings, it was found out that the content was able to extend the concentration span of the learners.

Wang & Reeves (2007) believe that what educators do to help students actively engage in learning may be more important to academic success than how much information is presented to them through instructional materials or other forms of instruction. Use of educational technologies with animations in the Science classroom not only helps with student understanding of content, but also positively impacts students’ engagement in lessons and their attitudes towards learning (Shu-Nu, et al., 2009).

Olsen and Clough (2001) state that simulations fascinate students and have the capability of grabbing and maintaining their attention in ways that interacting with a teacher, reading a book, seriously discussing ideas with other students and thinking about their own learning cannot. Akpinar and Ergin (2008) point out that animations stimulate more than one sense at a time. This makes the learners more attentive during the learning process and eventually they perform well. Findings from this study have revealed that use of IDC with animations extends concentration span of learners.

4.2.3 Effect of Animations on Learners’ Conceptual Understanding

The third objective of this study was to find out if animations embedded in IDC enhance conceptual understanding of text within IDC. This was determined by giving learners in the experimental schools IDC with animations while learners in the control schools were given
content without animations to use it for learning purposes. To be able to determine the effect of animations on performance, learners in the control group were given IDC without animations while their counterparts in the Experimental group were given IDC with animations.

According to Bakas and Mikropoulos (2003) learners enter the classroom with a wide range of misconceptions. When teachers know what their learners think, they can implement instructional activities to challenge existing student ideas. Learning activities, key inquiry questions and learning resources to use during the instructional process can be planned in advance as teachers target their students' misconceptions (Swain, 2012). According to Perkins, et al. (2006), According to Perkins, et al. (2006), animations are designed to facilitate teaching and learning through visualization and interacting with them helps in understanding Physics concepts clearer and easier. Use of animations and computer based simulations throughout instruction increases student’s understanding and achievement (Rosen, 2009). Use of animations in Physics IDC should help learners conceptualise concepts better and this leads to better performance. The null hypothesis in line with this objective stated that there is no significant difference in performance for learners who use e-learning materials with animations and those who use e-learning materials without animations. To test this null hypothesis effectively, t-test was conducted to establish whether the difference in the means posted by learners in the EG and CG was significant. Results of the performance of learners in both pre-test and post-test are key in testing this null hypothesis and they will be presented later in this section.

Teachers and learners were requested to respond to several items in a questionnaire which were meant to establish the extent to which the content helped them to conceptualise Physics concepts.
The ability of the content to enhance conceptual understanding of the text was also measured by stating the extent to which both learners and teachers found the animations relevant to the text. Four Physics teachers were involved in this study out of which 3 (75%) were males and 1 (25%) was a female. Their teaching experience varied from 5 years to 25 years. Learners also responded to questionnaire items meant to establish the level at which the content helped them conceptualise the Physics content. Physics content is better understood when the quality of teaching materials is high. Animations used in IDC are perceived to have the capability of making abstract concepts simpler for the learners. Quality content is developed using quality animations. Quality animations are supposed to be interactive and relevant to the text read by the learner. This study sought to establish whether the animations embedded in the Physics IDC are helpful in terms of assisting learners understand Physics concepts. One of the aspects of interest was whether each of the animations inserted was relevant to the concepts being taught. Views were sought from the subjects involved in this study and Table 4.6 gives some of the results.

Learners’ Responses on Ability of IDC to help in Conceptual Understanding

Learners were asked to respond to items which sought to establish the extent to which IDC helped them in understanding the topic on Refraction of light and Newton’s laws of motion on a three - pointer Likert scale. The scale had options of “Not at all”, “Made a slight difference” and “To a great extent”. Learners from both control and experimental schools responded to the questionnaire item in section “b” which had the two topics. Their responses are as shown in Table 4.6.
### Table 4.6: The Extent IDC Assisted Learners Understand Refraction of light

<table>
<thead>
<tr>
<th>Type of school</th>
<th>Control schools</th>
<th>Experimental schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Made a slight difference</td>
</tr>
<tr>
<td></td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>Content helped in understanding the topic “Refraction of light”</td>
<td>8</td>
<td>17.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>8.9</td>
</tr>
</tbody>
</table>

* *f* in the table represents the frequency of learners who selected the given response.

From Table 4.6, 26.8% of learners from the experimental group indicated that the content helped them to understand the topic of Refraction of Light with 64.3% of learners in experimental schools stating that IDC made a slight difference towards their understanding of the topic while only 8.9 % indicated that the content did not help them understand the topic at all. In general, 91.1% of learners from the experimental schools agreed to the fact that IDC assisted them to understand abstract concepts.

Learners from the control schools were also asked to indicate whether IDC helped them understand abstract concepts in the topic of “Refraction of Light”. Out of the responses given by learners on this questionnaire item, 17.4% indicated that IDC did not make any difference at all. Comparing this with 8.9% of learners in the experimental schools, it shows that learners in the experimental schools were assisted by the animations embedded in their IDC to understand the content in this topic better.
Table 4.7: The Extent IDC Assisted Learners Understand Newton’s Laws of Motion

<table>
<thead>
<tr>
<th>Type of school</th>
<th>Control school</th>
<th>Experimental school</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Made slight difference</td>
</tr>
<tr>
<td></td>
<td>f %</td>
<td>f %</td>
</tr>
<tr>
<td></td>
<td>8 17.4</td>
<td>23 50.0</td>
</tr>
<tr>
<td></td>
<td>14.3</td>
<td>17 30.4</td>
</tr>
</tbody>
</table>

*% represents the frequency of learners who ticked the given response.

The results from Table 4.7 show that 30.4% of learners in the experimental group were in agreement that the content helped them to understand the topic to a great extent while 55.4% of learners stated that the content made a slight difference to their understanding of the topic. On the other hand, 50.0% of learners in the control group indicated that the content made a slight difference towards understanding this topic.

In general, learners from the experimental schools agreed to a greater extent that IDC assisted them to conceptualise the concepts in Newton’s laws of motion. It was also revealed that 17.4% of learners in control schools indicated that IDC did not help them at all to increase the conceptualisation of this topic. A learner who used IDC without animations from one of the control schools had this to say “From my point of view is that the VCDs should show the full concept by explaining physically (normal appearing things), analytically up to mathematically step by step until a concept is fully explained and show the good relation of Physics and mathematics.” (CTR-JEH-L-J001).
Relevance of Animations Embedded in Physics IDC

Physics teachers and learners were given time to interact with all multimedia elements embedded in the Physics IDC. Relevance of the multimedia elements embedded in IDC determines the quality of the content and specifically its ability to help learners conceptualise different aspects of the content they use for learning purposes. Teachers and learners were asked to state their level of agreement regarding how relevant the animations were to the text they are embedded to. A five-pointer Likert scale was given to guide the choice of their responses. The scale had the options of ‘Strongly agree’, ‘Agree’, ‘Not sure’, ‘Disagree’ and ‘Strongly disagree’. The findings were analysed per the animations being studied and presented under the sub-headings which follow.

Relevance of Animation P31001 - Definition of Momentum

Teachers were given time to interact with all animations embedded in the topics of interest in this study. One of the animations they interacted with was embedded on the definition of momentum. All (100%) teachers strongly agreed with the statement that the animation is relevant to the text. This implies that all teachers found this animation very relevant to the text it is addressing. It was found to be simplifying the term momentum and giving learners a relevant visual which correctly illustrated what momentum refers to.

Relevance of Animation P31002 - Newton’s Second Law of Motion

Teachers interacted with animation P31002 which was meant to visualize and simplify the Newton’s second law of motion. They manipulated the animation and tried to relate it with what the law states. Later, they rated the relevance of this animation on the given Likert Scale. It was revealed that 50% of teachers who interacted with this animation strongly agreed that it is relevant to the Newton’s second law of motion. In addition to this, 50% of the respondents
agreed that the animation is relevant. None (0%) of the teachers disagreed or strongly disagreed that the animation is relevant to Newton’s second law of motion. From the responses received from Physics teachers, it implies that the animation is relevant to the law it is meant to simulate but there is still room for improvement.

**Relevance of Animation P31003 - Impulse**

Teachers gave their responses indicating their level of agreement with the statement seeking to establish whether the animation attached to the concept of impulse is relevant or not. It was established that 50% of teachers who interacted with this animation strongly agreed that it is relevant to the concept of impulse. In addition to this, 50% of the respondents agreed that the animation is relevant. None (0%) of the teachers was uncertain, disagreed or strongly disagreed that the animation is relevant to impulse. From these responses, it implies that the animation is relevant to the concept it is meant to visualize and simplify.

**Relevance of Animation P31004 - Newton’s Third Law of Motion**

The animation embedded to simplify the Newton’s third law of motion was also rated by teachers pertaining to its relevance. The animation was a visualization meant to help learners understand Newton’s third law of motion. The responses received imply that teachers were satisfied with the animation since 100% of the respondents indicated that the animation was relevant. The fact that none of the teachers disagreed or strongly disagreed that the animation is relevant does not mean that it is perfect. It is worth noting that none of the teachers strongly agreed that the animation was relevant and this means there is room for improvement.
Relevance of Animation P31005 - Recoil Velocity

Recoil velocity is another concept which had an animation embedded on it for learners to understand the concept better and easier. It was designed using locally available materials which learners are able to relate with. The analysed data revealed that 50% of teachers strongly agreed that the animation is relevant to recoil velocity while the remaining 50% of curriculum implementers stated that it is relevant. In summary, 100% of the teachers were in agreement with the fact that the animation is relevant. None of the teachers disagreed with the statement that the animation is relevant to the concept of recoil velocity.

Relevance of Animation P31006 - Elastic and Inelastic Collisions Combined

Teachers interacted with the simulation embedded to simplify and help learners visualize the concept of both elastic and inelastic collisions combined in one animation. The findings show that 50% of the respondents strongly agreed that the animation is relevant while the remaining 50% agreed that it is relevant. Relevance in this case means that the animation is addressing the concept of collisions appropriately as required. It has visuals which are in line with the concept that learners were studying. When the animation is relevant, learners are able to grasp the concepts of elastic and inelastic collisions with more ease. In addition to this, retention of the information they get about collisions is retained for a longer period compared to when learners are not exposed to the animation.

Relevance of Animation P31007 - Elastic Collisions

Responses pertaining to relevance of the animation embedded on the concept of elastic collisions were also sought from the respondents. Curriculum implementers gave their honest opinions on whether the animation was relevant to this concept or not. It was revealed that this animation was very relevant to the concept of elastic collisions. All (100%) teachers indicated that the
animation is relevant to the text. All (100%) teachers indicated that the animation was very relevant to the text. This means that it is able to assist learners in understanding the concept of elastic collisions.

**Relevance of Animation P31008 - Inelastic Collisions**

Teachers’ responses pertaining to relevance of the animation embedded on the concept of inelastic collisions were also sought. It was found out that 100% of teachers responded to the affirmative that the animation embedded to the concept of inelastic collisions is relevant. None (0%) of the teachers was uncertain, disagreed or strongly disagreed with the statement that the animation is relevant to the text.

**Relevance of Animation P31009 - Law of Conservation of Linear Momentum**

Like in the other animations, teachers gave their opinions on whether the animation embedded on the law of conservation of linear momentum is relevant or not. The visuals used in this animation were similar to the ones used in the previous animations about collisions. The results show that 50% of the teachers involved strongly agreed that the animation is relevant while the rest 50% agreed that the animation is relevant to the text it is embedded to. The text is about how linear momentum is conserved when two bodies collide. The same text is visualised by the animation in a way that learners are able to conceptualize the concept with ease. According to Dale (1969) visuals assist learners to retain the information learned for a longer period.

**Relevance of Animation P31010 - Fluid Friction (viscosity)**

Viscosity is a concept which is abstract to many learners. It is friction that is experienced within fluids. Teachers interacted with the animation embedded on the text explaining viscosity. They were later given a questionnaire to indicate their level of agreement with the statement that the animation is relevant to the
text. The results revealed that all (100%) teachers who reviewed this animation agreed that it is relevant to the text. None of the teachers disagreed or strongly disagreed with the statement that the animation is relevant to the text. This means that learners are able to grasp the concept of viscosity better if they read the text, play and view the graphics displayed as the animation runs.

**Relevance of Animation P31011 - Introduction of Refraction**

The concept of refraction was simulated in an animation using a ray and two media of different densities. As the animation runs, a ray of light is generated and the phenomenon of refraction is observed as it crosses from the less dense medium to the denser medium. The analysed responses show that 50% of the teachers strongly agreed that the animation is relevant while the remaining 50% agreed with the statement that the animation is relevant. Once again, none (0%) of the teachers were either uncertain, disagreed of strongly disagreed with the statement that the animation is relevant to the text.

**Relevance of Animation P32002 - Refraction**

Teachers gave their responses on this animation as well about the relevance of this animation. The responses displayed show that 100% of the respondents strongly agreed with the fact that the animation is relevant to the text. The graphics used are fully in line with the text explaining what refraction is. None of the teachers was uncertain or disagreed with the fact that the animation is relevant to the text. The teachers who reviewed this simulation are experienced in teaching the subject and this implies that this animation has the potential of helping learners understand the concept of refraction with much ease.
Relevance of Animation P32003 - Critical Angle

Teachers gave their responses on the animation pertaining to critical angle. The animation was well illustrated using two media and a ray of light was displayed moving from the denser medium to the less dense medium. The animation clearly shows the behaviour of the incident ray when the critical angle is reached. Teachers indicated their level of agreement with the statement that the animation is relevant to the text. Half (50%) of the teachers who reviewed this animation strongly agreed that it is relevant to the text. The remaining 50% agreed with the statement that it is relevant while none (0%) of the teachers was uncertain or was in disagreement with this statement.

Relevance of Animation P32004 - Total Internal Reflection

One of the conditions necessary for total internal reflection to occur is that a ray of light has to travel from a dense medium to a rarer medium. The other condition is that the angle of incidence of the light ray must exceed the critical angle of the interface. These two conditions were considered when designing the animation and the graphics were carefully developed to bring out the phenomenon of total internal reflection. Teachers gave their honest opinions indicating their levels of agreement with the statement that the animation is relevant to the text.

The results revealed that 100% of the respondents who reviewed this animation agreed that it is relevant to the text. None of the teachers disagreed or strongly disagreed with the statement that the animation is relevant to the text. This means that learners are able to grasp the concept of total internal reflection better if they read the text, play and follow the graphics displayed as the animation runs. The visuals in the animation also make learners retain much of what they learn.

Relevance of Animation P32005 - Prism Periscope

In Physics, the biggest challenge is to procure and give learners the opportunity to interact with some of the learning resources. Animations give the learners an opportunity to interact with
some of the most expensive instruments virtually. This animation simulated the working of the prism periscope. All teachers (100%) were in agreement with the statement that the animation is relevant to the text. None (0%) of the teachers was in disagreement with the statement that the animation is relevant. The graphics used in the animation are able to simulate how the prism periscope works and learners are able to follow and understand.

**Relevance of Animation P32006 - Optic Fibre**

Teachers interacted with animation P32006 which was meant to simulate how optic fibre works. Optic fibre and the prism periscope are some of the applications of total internal reflection. They manipulated the animation and tried to relate it with what is expected. Later, they rated the relevance of this animation on the given Likert Scale to indicate their level of agreement with the statement that the animation is relevant to the text.

The results show that 50% of the teachers involved in the study strongly agreed that the animation is relevant while the rest 50% agreed that the animation is relevant to the text it is embedded to. The text is about the working of an optic fibre as an application of total internal reflection. The animation visualises the text using this animation in a way that learners are able to conceptualize the concept with ease.

**Relevance of Animation P32007 - Dispersion of Light**

Teachers were able to play and observe the animation showing how light is dispersed. They reviewed the animation and gave their responses on whether it is relevant to the text or not. The findings revealed that 50% of teachers strongly agreed that the animation embedded is relevant to the text. In addition to this, the remaining 50% of teachers agreed that the animation is
relevant. No teacher was either uncertain, disagreed or strongly disagreed with the statement that the animation is relevant to the text.

In general, teachers either strongly agreed or agreed with the statements that the animations are relevant to the theories, laws, principles and concepts they are helping learners to visualize. Relevance of multimedia elements is very important in IDC. For animations to serve their purpose effectively, they should be relevant.

**Relevance of Animations Embedded on IDC as Rated by Physics Learners**

Learners were also asked to determine the relevance of animations embedded to the text within IDC. Learners from the control school were not given this item because their IDC did not have animations. Table 4.8 gives the responses of learners from the experimental schools.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Not sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animations in content are relevant to text</td>
<td>22 (39.3%)</td>
<td>23 (41.1%)</td>
<td>4 (7.1%)</td>
<td>7 (12.5%)</td>
<td>0 (0.0%)</td>
</tr>
</tbody>
</table>

The results in Table 4.8 show that 80.4% of the learners from the experimental schools indicated that animations embedded within IDC were relevant to the text. Animations which are relevant to the text help learners to conceptualise Physics content with much ease. When learners conceptualise concepts better, their performance improves.

Dikmenli, *et al.* (2018) conducted a study which sought to establish whether animations were of any significance in increasing the conceptual understanding of learners about earthquakes. The sample of the study had 16 boys and 15 girls for the control group. The experimental group
comprised of 17 girls and 14 boys. Data was collected using an academic success test with multiple choice questions which has 4 selection options. This test was used for both pre-test and post-tests. The study took four (4) weeks and the data collected was analysed. The pre-test scores of the control and experimental groups were 14.39 and 15.61 respectively. The post-test scores of the control and experimental groups were 15.61 and 19.13 respectively. These findings show that use of content with animations helped learners to conceptualize concepts about earthquake better.

Findings from this study have revealed that relevant animations used assisted learners to conceptualise the text better. Quality and relevant animations assist learners to have a deeper understanding of Physics concepts, theories, laws and principles. Content developers should design and produce quality content with well thought out animations which can enhance understanding of Physics concepts.

**Other Attributes for Rating Quality of Physics IDC by Physics Teachers and Learners**

One of the attributes used to determine the quality of interactive content is its ability to help learners understand abstract concepts easier through its ability to help them visualise the concepts with much ease. When visualisation takes place with ease, learners form their mental images with ease. The formed schemes then help learners to store information in the long-term memory. In addition to this, the mental images assist learners to retrieve the stored information with much ease. Teachers and learners were given an instrument with items meant to assist in establishing the ability of the content to help learners to visualise and understand abstract concepts. The instrument helped teachers and learners to rate the quality of IDC that was
presented to them on a Likert scale. They stated their levels of agreement with some statements designed with attributes of content quality. Their responses are shown in tables 4.9a and 4.9b.

**Table 4.9a: CG Learners’ Ratings on Quality of Physics IDC**

<table>
<thead>
<tr>
<th></th>
<th>Control schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
</tr>
<tr>
<td>Content has features which help one understand concepts better</td>
<td>23</td>
</tr>
<tr>
<td>Content helps one in visualizing abstract ideas</td>
<td>20</td>
</tr>
</tbody>
</table>

Findings from Table 4.9a show that 50% (23) of the learners strongly agreed that the content helps them to understand concepts better and 37% (17) agreed to this statement as well and 6 (13%) learners were not sure. Pertaining the ability of the content to help learners visualize abstract ideas, 43.5% of the learners strongly agreed that the content enabled them to do so. 39.1% of learners agreed to this statement and only 1 (2.2%) learner disagreed with this statement.

More than 87% of the learners indicated that interactive content has the ability to help them understand concepts better. On the aspect of visualising abstract concepts, 82.6% of the learners stated that the content assisted them to visualise abstract concepts. Since the content did not have animations, learners in this questionnaire item were referring to the other multimedia elements found within the content like videos, illustrations, photographs and audio. They found these elements good enough to help them visualise and understand Physics concepts within IDC with much ease.
Table 4.9b: EG Learners’ Ratings on Quality of Physics IDC

<table>
<thead>
<tr>
<th>Experimental schools</th>
<th>SA</th>
<th>A</th>
<th>NS</th>
<th>D</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>Content has features which help one understand concepts better</td>
<td>24</td>
<td>42.9</td>
<td>26</td>
<td>46.4</td>
<td>5</td>
</tr>
<tr>
<td>Content helps one in visualizing abstract ideas</td>
<td>11</td>
<td>19.6</td>
<td>29</td>
<td>51.8</td>
<td>14</td>
</tr>
</tbody>
</table>

The tabulated findings from Table 4.9b show that 42.9% (24) of the learners strongly agreed that the content helps them to understand concepts better and 46.4% (26) agreed to this statement as well. Some learners (8.9%) were not sure about the ability of the content to help them understand concepts better. Pertaining the ability of the content to help learners visualize abstract ideas, 19.6% of the learners strongly agreed that the content enabled them to do so. It was also found out that 51.8% of learners agreed to this statement and only 2 (3.6%) learners disagreed with this statement.

Majority (89.3%) of the learners from experimental schools indicated that the content helped them to understand abstract concepts better. At the same time, 71.4% of learners indicated that the content helped them in visualizing abstract ideas. These two attributes are closely related and they refer more to enhancement of conceptual understanding of Physics content.

Physics Teachers’ Responses on Capability of IDC to Simplify Concepts

Physics teachers’ responses on the ability of the content to help learners visualise abstract concepts were analysed. The findings showed that 100% of the teachers agreed to the fact that the content has features which help learners to understand Physics concepts better. 100% of the teachers also indicated that the content is capable of helping learners visualise abstract ideas.
Content which has multimedia elements with the capability of assisting learners visualise abstract concepts can increase the conceptual understanding of text within a given learning area and this is manifested through improved performance.

Jonas P. & Weimer, D. (1999) conducted a study for two years and it involved five colleges and universities. During the study, academic achievement was measured by Educational Testing Service (ETS) Major Field Assessment Test (MFAT) among students taking Business in traditional undergraduate programmes and those in non-traditional accelerated adult degree programmes. The study also compared the subjects’ test results with national norms and analysed the relationship of the MFAT and grades in traditional and non-traditional business programmes. During the pre-test, 122 traditional undergraduate students and 209 non-traditional students took the pre-test ETS MFAT and 81 students completed the post-test MFAT. Undergraduate non-traditional students scored slightly higher on average in the ETS MFAT than the traditional undergraduate students. During post-test, 173 of the students who took the ETS test originally re-took it after completing their major courses. This study compared matched pairs of traditional or non-traditional students and also found that non-traditional students scored higher on the post-test than did the traditional students. The non-traditional students were taught using computer aided instructions with animations.

The results from this study show that use of digital content with animations has the capability of helping learners understand the abstract concepts with ease. This leads to improved conceptual understanding of concepts found in a particular learning area and hence better performance.
Analysis of the Pre and Post Tests for CG and EG

The effect of the interventions put in place during the instructional process are assessed through performance of learners. During the study, learners in both experimental and control schools were given pre - tests to determine their entry behaviour. Subjects in the EG were given IDC with animations. The CG was given IDC without animations as part of the treatment during this study. After the treatment was given, they were given the post-test to establish if the animations had an effect on performance of learners in both groups. The scores from the pre - test and post-test were analysed and findings presented in tables and paragraphs which follow. It is worth noting that the raw scores posted by learners in both CG and EG were converted into percentages. The analysis makes a comparison between the CG and EG. Table 4.10 shows the performance of learners in the pre - test.

Table 4.10: Performance of Learners in Pre - Test

<table>
<thead>
<tr>
<th>Study group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean (σ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre - test scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>46</td>
<td>11.35</td>
<td>13.52</td>
<td>1.99</td>
</tr>
<tr>
<td>Experimental</td>
<td>58</td>
<td>15.40</td>
<td>11.93</td>
<td>1.56</td>
</tr>
</tbody>
</table>

The pre - test was conducted to determine whether the control and experimental groups considered for the study were of similar ability and the sampled schools were equally equipped in terms of ICT resources. The total number of subjects considered in this study for the control and experimental groups were 46 and 58 subjects respectively. The mean and standard deviation
of the control schools in the pre-test was 11.35 and 13.52 respectively. On the other hand, from Table 4.10, the mean and the standard deviation of the experimental group in the pre-test was 15.40 and 11.93 respectively.

Comparison of the means posted by the control and the experimental groups in the pre-test was done using t-test. The t-test was conducted to give extra assurance that the difference between the two means was either significant or not. Table 4.11 gives the results obtained after conducting the t-test.

**Table 4.11: Comparison of Means of Control and Experimental Groups in Pre-test**

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Pre-test scores</td>
<td>0.23</td>
<td>0.64</td>
</tr>
</tbody>
</table>

From Table 4.11, for the pre-test, the t-statistics gave t (90.48) = -1.60, p = 0.64. The calculated value t is simply the calculated difference represented in units of standard error. The greater the magnitude of t, the greater the evidence against the null hypothesis. This means there is greater evidence that there is a significant difference. The closer t is to zero, the more likely there is no significant difference. At the same time, the value of p should be less than 0.05 for the t value to
be significant. In our case, the value of t is close to zero and the p value is more than 0.05. This implies that the means posted by the EG and CG in the pre - test are not significantly different. In other words, the performance of learners from experimental and control groups in the pre - test was similar. This means the two groups were almost of similar ability and they were equally equipped in terms of learning resources. Their entry behaviour was almost the same and this further implied that quasi-experimental design could be used to conduct the study.

The level of learner’s knowledge in the Physics concepts drawn from the topics of Newton’s Laws of motion and Refraction of Light was almost the same for learners belonging to the two groups. By extension, their knowledge of the laws, theories and principles related to these two topics is also the same. The effect of administration of the treatment to the experimental group can be clearly seen when the two groups start while having almost similar entry behaviour.

The findings from the pre - test show that the control and the experimental groups were of similar ability. Learners from the two groups had almost the same entry behaviour and this means the effect of introducing the treatment was to be clearly noticed from the results posted by experimental group after administering the post-test.

During the study, a post-test was administered after the pre - test. Learners were given fourteen (14) weeks to interact with the learning resources before the post - test was administered. Table 4.12 shows the results posted by the control and experimental groups after a post-test was administered.
Table 4.1: Performance of Learners in the Post - Test

<table>
<thead>
<tr>
<th>Study group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Post - test scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>46</td>
<td>12.88</td>
<td>15.26</td>
<td>2.25</td>
</tr>
<tr>
<td>Experimental</td>
<td>58</td>
<td>25.27</td>
<td>20.19</td>
<td>2.65</td>
</tr>
</tbody>
</table>

In the post-test, the control group posted a mean of 12.88 with a standard deviation of 15.26. After treatment was administered, the experimental group posted a mean of 25.27 with a standard deviation of 20.19. To check whether the difference in the means posted was significant, a t - test was conducted on the means posted by the control and experimental groups for the post-test. Table 4.13 gives the results obtained after conducting the t - test.

Table 4.13: Comparison of Means of Control and Experimental Groups in Post - Test

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Std. Sig.</td>
<td>Mean Error Difference 95% Confidence Interval of the Difference</td>
</tr>
<tr>
<td>t</td>
<td>Df (2-tailed)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Post - test scores</td>
<td>3.456</td>
</tr>
</tbody>
</table>
The post-test results show that $t (104) = -3.45, p = 0.001$. The difference between the means of the control and experimental groups is larger in the post-test results. It is also worth noting that the difference between the means posted by the control and experimental groups is significant. This means that after administering the treatment to the experimental group, which in this case is IDC with animations, the learners’ performance improved to a certain extent. IDC with animations had an effect on the learners’ performance. Learners in the control schools were given IDC without animations and this caused the significant difference in the means of the two groups.

This study aimed at establishing whether animations embedded in Physics IDC are effective in terms of improving learners’ performance. The pre-test and post-test results were administered to assist in establishing this. The findings displayed from the experimental group can be used to make several inferences. The number of subjects involved in the experimental group was 58 (N=58). As mentioned earlier, learners in the experimental group posted a mean of 15.40 in the pre-test and the standard deviation was 11.93. After the treatment was administered, they posted a mean of 25.27 with a standard deviation of 20.19. This indicates that they improved to a great extent. This improvement can be attributed to the treatment which was given to the subjects which in this case is IDC with animations.

Animation refers to simulated motion pictures showing movement of drawn objects (Musa, et al., 2013). Animations enable learners to see pictures and other graphics with motion. They further assert that using animations in education activities assists in explaining abstract subjects in a more concrete way, developing representational process of individuals hence making
learning more fun, a more permanent activity and offering a rich teaching resource for educators. Appropriate, suitable and on-time use of animation supports the learning process.

Dikmenli, *et al.* (2018) asserts that there is a significant difference between learners who are taught using animated films and those taught without animated films. They conducted a study whose main objective was to establish the effect of animation film use on earthquake knowledge level of 4th grade learners. It was found out that the experimental group was more successful than control group in terms of academic success and animation film use in earthquake knowledge level of 4th grade learners led to improved performance.

According to Perkins, *et al.* (2006), animations are designed to facilitate teaching and learning through visualization and interacting with them helps in understanding Physics concepts clearer. Rosen (2009) points out that use of animations and computer based simulations throughout instruction increases student’s understanding and achievement (Rosen, 2009). Yigal (2009) studied the effect of an animation-based online learning environment on transfer of knowledge and on motivation for Science and technology learning. The study revealed that there was a significant impact of animation-based online learning environment on transfer of knowledge and on learning motivation.

Adegbija & Falode (2014) conducted a study on the effect of animation-based camstudio Physics instruction on secondary school students’ performance in Minna, Nigeria. The findings of the study revealed that animation-based camstudio Physics instruction improves students’ achievement scores in Physics. It increases motivation of learners while learning and this leads to
increased interest. Students taught Physics using animations performed significantly better than their counterparts taught Physics using conventional lecture method.

Ummeh and Fawzia (2014) examined the effect of using computer animation in teaching Chemistry at Advanced level. During the study, an attempt was made to enhance students’ conceptual understanding of the “Chemistry of Life” through use of computer animations. The findings revealed that use of computer animations has a positive impact on students’ motivation, interest and engagement, leading to enhanced conceptual understanding. This further leads to improved performance.

The findings from this study agree with the findings from other studies conducted elsewhere. Use of IDC with animations during the teaching and learning process leads to improved performance. From this study, it has been seen that the means posted by the control and experimental groups differ significantly after introduction of the treatment. The experimental group posted a higher mean in their post-test after learning using IDC with animations. Teachers in the experimental schools supported the fact that IDC with animations was useful in improving understanding and eventually performance of learners in Physics. This is an excerpt from one of the teachers teaching in School A:

“The digital content is very resourceful in demystifying and enhancing the learning of Physics as a subject. However, the content requires learners to have computer or smart phone with some basics on the use of a computer. Some good videos and animations should be repackaged for consumption using other platforms like WhatsApp. I highly recommend it.” (EXP- ND-PT001).
Another teacher from an experimental school indicated that while using the Physics IDC as a complementary learning material, learners are able to conceptualise abstract concepts within the content.

Further, Dale (1969) indicates that learners retain more information by what they “do” as opposed to what is “heard”, “read” or “observed”. Experiential learning or action learning is what educators should be using to ensure that students learn effectively. He further argued that learners generally remember ninety percent (90%) of what they do as they perform a task. The interactivities in animations engage learners to the extent of doing where Dale indicated that optimum learning takes place. The aspect of interacting with the animations made learners very interested in the content and this led to increased Academic Learning Time (ALT).

According to Dikmenli (2018), use of animations increases learner’s knowledge on a subject where the animation is used. It also increases the permanency of the knowledge acquired. Animations help learners in creating mental images which are very useful when storing knowledge in the long-term memory.

In regard to the quality of IDC, learners using content designed for the control schools indicated that their content needs more interactivities. For example, one learner indicated that “visual images should be increased to make learning more understandable” (CTR-JEH-L-J018). Another learner indicated that “more illustrations should be made on refraction of light” (CTR-JEH-L-J013). Another learner praised the content and stated that:
“The programme has actually helped a lot because one can read whenever he/she is interested like I. I think if the system is introduced, learning will be much easier through continuous reading will help us remember through the information being stored in a long-term mind. Practical should be done practically and steps followed so through this during exams we will remember so easily. Otherwise I support your programme keep it up!” (CTR-JEH-L-J018).

A teacher from one of the control schools also made his comment on the field of additional comments. This is an excerpt from a Physics teacher teaching in one of the control schools.

“More illustrations based on the day to day life situation will enhance concentration. All content (audio) to have a video / visual support. At break point, more time (commercial breaks) this will ensure learners get to track. Theory questions were many as opposed to numerical questions. We should add more numerical questions. Practical questions need to be added. The content was easy to navigate through. The learners used the content very few times”. (CTR-JEH-PT004)

These comments from Physics teachers and learners indicate that IDC needs to have more interactivities and more so the visuals. Animations have visuals which assist learners in formation of schemas. The visuals also simplify abstract concepts and make them clearer. Learners reflect on their experiences and thereafter construct their own understanding of their world (Driver, et al., 1994). This is in line with constructivism which focuses on how learners construct their own knowledge. Jean Piaget defined accommodation and assimilation as ways in which new knowledge is built upon previous knowledge. Educational media assists learners during the processes of accommodation and assimilation. In the case of this study, IDC with
animations is the educational media the subjects were exposed to. After using animations in the teaching and learning process, learners generated their own rules and mental models which they later used to assist them make sense of their experiences. Animations assist learners to create the mental images and when they come across new experiences, they go through the process of adjusting the mental images to accommodate the new experiences. Teachers’ comments agree with the findings of the study conducted by Barak, et al. (2011) which showed that use of animated movies promoted students’ explanation ability and their understanding of scientific concepts. Animations make IDC more interactive and increase its quality.

Use of interactive content with animations enhances learner’s understanding. Boud & Feletti (1999) argue that teachers should use multimedia to modify the contents of the learning materials used by learners for learning purposes. They further state that when teachers use different multimedia elements in their teaching, learning becomes more meaningful. By incorporating digital media elements like animations during the learning process, students are able to learn better since they use multiple sensory modalities, which would make them more motivated to pay more attention to the information presented and hence retain the information for a longer time.

In a study done by Rivers and Vockell (1987) they found that computer animations have been found to enhance learners’ active involvement in the learning process, enabling them to apply principles more often, and helped learners to meet the learning unit goals. Learners who used the guided version of the animation performed better in the tests of scientific and critical thinking than the learners in the control group. The results from this study agree with the study done to
establish the effect of animations in e-learning materials on students’ performance in Physics. In both studies, learners taught using IDC with animations performed better.

Another study was done by Jimoyiannis and Komis (2001) which examined the effect of using computer animations on learners’ understanding of basic kinematics concepts concerning simple motions through the Earth’s gravitational field. The findings revealed that computer animations led to increased learner’s content knowledge. Learners who used the computer animation in addition to traditional instruction achieved significantly higher results on the research tasks. The study recommended that computer animations can be used as a complement to other forms of instruction in order to facilitate learners’ understanding. When learners understand concepts better, they perform better in a subject. These findings are also agreeing with what was found in this study.

Udo & Etiubon (2011) did a study in which they investigated the relative effect of computer-based Science simulations on learners’ achievement at the secondary school level when compared with traditional expository teaching methods. The pre - test and post - test scores showed that learners taught by computer-based Science simulations performed significantly better than those taught using the traditional expository method. These results are also in agreement with the findings of this study. Swain (2012) points out that the strategy used during the teaching and learning process in a Science classroom should engage learners actively for
maximum achievement to occur. The incorporation of computer animations and models provide enhancement and relevance to Science learning.

From the observations made during the study, the improved performance and the findings revealed from the data collected from Physics teachers and learners indicated that animations help learners in understanding abstract concepts. The visualizations designed when developing animations assist learners to have an in-depth understanding of Physics concepts, laws, theories and principles. The pre-test and post-test analysis of both study groups assisted the researcher in establishing the effect of animations embedded in the Physics IDC to a great extent. Quantitative and qualitative data obtained from the observation schedule, teachers’ and learners’ questionnaires aided a lot in establishing the ability of IDC to assist learners in understanding abstract Physics concepts. Quality animations have an effect in the teaching and learning process. Their effect in this study was seen through the improved performance in Physics. This therefore leads to rejection of the null hypothesis of this study which states that there is no significant difference in performance between learners who are taught using e-learning materials with animations and those who are taught using e-learning materials without animations.

4.3 Instructional Model using ICT (Animations)

An instructional model can be defined as the depiction of teaching and learning environment, including the behaviour of facilitators and learners in a lesson or specified environment. Models of teaching are the specific instructional plans which are designed according to the relevant learning theories. A model provides a comprehensive blue print for a curriculum to design instructional materials, planning lessons, teacher - learner roles and teaching aids (Rafeedalie, 2018). Joyce, B., Weil, M. and Calhoun, E. (2003) define an instructional model as a description
of a learning environment, including our behavior as teachers when that model is used. Eggen (1979) defines instructional models as prescriptive teaching strategies which assist teachers to realize specific instructional goals. Instructional models are guidelines or sets of strategies on which the approaches to teaching by instructors are based. Effective instructional models are based on learning theories. These learning theories describe the process that propose how people can learn new ideas and concepts. With the current emphasis on standards-based education, teachers everywhere are searching for programs and practices that have greater effect on student achievement. Models represent the broadest level of instructional practices and present a philosophical orientation to instruction. Models are used to select and to structure teaching strategies, methods, skills, and student activities for a particular instructional emphasis. Joyce, et al. (2003) identify four classes of models: information processing, behavioural, social interaction and personal. All these models can be used during a relevant instructional process.

One of the objectives of this study was to develop an instructional model on how to use animations effectively for improved performance in Physics. The model outlines several aspects pertaining to teacher preparation, selection of an appropriate instructional strategies and methodologies, integration of technology in learning and use of digital resources with animations. It is important to note that effective application of animation during the teaching process depends on the teachers’ knowledge on the principles and practice guiding its application, the characteristics of the learners and the objectives of the lesson (Kwasu A. & EmaEma, 2015). The model is developed in steps based on the study findings.
Step One:

Figure 4.5: Step One towards Development of the Instructional Model

Physics is an important subject among the core Science subjects taught at secondary school level in Kenya. Physics is a natural Science that deals with the study of matter in relationship to energy. Physics content is structured into three main categories, namely, theoretical Physics, mathematical Physics and experimental Physics. The study of Physics thus provides an ideal preparation and a prerequisite for pursuing a number of careers in Sciences. Knowledge in Physics, can lead to an engineer, medical doctor, radiographer, meteorologist, optician, research scientist among others. The knowledge of Physics provides an individual with useful information in solving everyday life challenges. Studies have shown that Physics contributes a lot towards the understanding of matter and what exists in the environment. Physics education and research benefits society in numerous intangible and tangible ways. The intangible contributions of Physics include an ever more fundamental understanding of the physical universe and the satisfaction of the deeply human instinct to comprehend the order and majesty of the world in which we live (Tsang, C., Abarbanel, H., Connell, G., Lanzerotti, L. and Sullivan, J., 2018).

The concepts to be taught in Physics are usually drawn from the Physics curriculum. In the Kenyan curriculum, Physics syllabus has forty one (41) topics. These topics cover the entire
curriculum for Form 1 to Form 4. Physics concepts, laws, principles and theories to be taught are outlined in the syllabus. The Kenyan Physics curriculum is spiral in nature and learners need to master the subject matter right from primary Science up to the end of secondary school level. At the primary school level, Physics content is integrated with Chemistry, Biology and Technology and packaged in a subject called Science. Learners therefore need to master the Science taught at primary school level well for them to grasp Physics subject matter taught in secondary school with ease.

Physics teachers should prepare adequately before they present Physics lessons to learners. Schemes of work for teaching Physics should be well prepared. While preparing schemes of work, Physics teachers should make sure that content to be taught is drawn from the syllabus. It should be sequenced in a logical manner starting with the simple concepts drifting towards the complex ones. The methods to be used while teaching these concepts should be carefully selected. Studies have shown that teacher centred methods are not effective while teaching Science subjects and therefore they should not be emphasized in the schemes of work. Yisa and Ojiaku (2016) identified use of traditional teaching methods coupled with inadequate use of ICT and other technological devices as some of the factors which render the teaching and learning process passive. When teachers use traditional methods of learning and also fail to integrate ICTs in the teaching and learning process, concepts appear more abstract to learners during the instructional process. Teachers of Physics should therefore be encouraged to use constructivist – based pedagogies while teaching. Alsulami (2016) points out that use of constructivist – based approaches while teaching changes the way of thinking among learners and boosts the motivation for learning when applied gradually. When Physics teachers in this study used constructivist – based approaches together with technology during the learning process, performance of
the learners in Physics improved. Moreover, use of educational technology in the Science classroom not only helps with student understanding of content, but also positively impacts on students’ engagement in lessons and their attitudes towards learning (Shu-Nu, *et al.*, 2009). The scheme of work should therefore make suggestions of the resources, and in this study, the ICT resources to be used in the teaching and learning process and the appropriate constructivist – based approach to use during the instructional process.

After preparation of ICT integrated scheme of work, ICT integrated lesson plans should be prepared. These lesson plans should make deliberate efforts to ensure ICTs are used during the teaching and learning process. The teacher should ensure the needed resources like computing devices are in good working form and adequate in number. The need to use technology cannot be overemphasized. Swain (2012) points out that the major focus of current Science teaching should be to promote student understanding and application of scientific knowledge and inquiry processes which lead to problem solving abilities. Yang and Heh (2007) state that to achieve this goal, Science educators must attempt to find a well-developed computer- assisted learning environment that integrates the rationales of pedagogy and cognitive-approach psychology with computers to improve Science learning.

After development of ICT integrated schemes of work, lesson plans and ensuring that ICTs are available, the next step is delivery of content in the classroom. Teachers should master the content they want to teach, identify the correct methodologies to use, select the ICTs and other technologies to be used during lesson delivery. Physics and Science teachers need to be trained on one of the key models used to effectively integrate ICT in the teaching and learning process. One of the effective models used globally is the TPACK model.
Koehler, M. J., & Mishra, P. (2005) developed the TPACK framework which focuses on technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). This model provides a simplified strategy while offering practical solutions to the challenges teachers go through while integrating technology in the learning process. Teachers need to differentiate content knowledge (CK) which refers to what is being taught from the instructional method being used to deliver the content. Knowledge of the teaching method is referred to as pedagogical knowledge (PK). Finally, they also have to understand the technology to use while keeping in mind that they should choose the most appropriate technology while teaching the
Physics content. This order is important because the technology being implemented must communicate the content and support the pedagogy in order to enrich students’ learning experience. The technology to use encompasses interactive digital content. Teachers should select the interactive content to use carefully for the learning outcomes to be realised during the learning process. During this study, Teachers of Physics were trained on how to prepare ICT integrated lesson plans and on how to teach using technology before the treatment was administered to the experimental group. Figure 4.7 gives a summary of step two.

**Step Two:**

![Diagram](image)

**Figure 4.7: Step Two towards Development of the Instructional Model**

Teachers of Physics should be careful to select content which has relevant quality animations for use during the instructional process. Rosen (2009) indicates that using educational technologies such as animations, interactive computer programs and various other technologies throughout instruction increases student understanding and achievement in content knowledge. Swain (2012) agrees with Rosen (2009) by indicating that use of computer animations help foster student engagement, perceptions and learning. Moreover, incorporation of computer animations and models provide enhancement and relevance to Science learning. The findings of this study have also shown that use of animations in the teaching of Physics leads to improved performance.
Studies have shown that through the use of animations, learners are more actively engaged and motivated during the learning process (Swain, 2012). The findings of a study conducted by Geban, Askar & Ozkan (1992) showed that use of animations in Science education promotes positive attitudes towards Science courses and that computer based simulations help learners acquire Science process skills to a greater extent compared to when conventional methods are used. This study sought to establish whether use of IDC with animations adds any instructional value in the learning of Physics. It found out that, they motivate learners and engage them for a longer period. This increases their Academic Learning Time (ALT) and hence they gain more Physics knowledge. Figure 4.8 shows a summary of the effect of using animations on learners’ interest and motivation.

**Step Three:**

![Diagram of Instructional Model]

**Figure 4.8: Step Three towards Development of the Instructional Model**

The major objective of this study was to establish whether use of IDC with animations has an effect on the conceptual understanding of Physics. The findings from the study have shown that learners’ conceptual understanding increases and this was manifested through improved
performance in Physics. The difference between the means of Experimental Group (EG) and the Control Group (CG) was significant implying that IDC with animations had an effect on conceptual understanding of learners in Physics. Learners who used IDC with animations performed better. This is in line with findings from other studies conducted elsewhere in the world. According to Nurul, et al. (2019) learners do not clearly understand concepts in Physics if there is no direct demonstration through which they observe. Physics content can be understood easier with the help of animations. Perkins, et al. (2006) point out that animations are designed to facilitate teaching and learning through visualization and they help learners in understanding Physics concepts clearly. Use of animations and computer based simulations during instruction increases learner’s understanding and achievement (Rosen, 2009). When learners use content with animations, they are able to note the key sub – concepts in Physics while learning. This helps them to conceptualize key concepts and internalize them thus leading to improved performance in Physics. Figure 4.9a shows the composite model generated from the findings of this study.
Step Four:

Figure 4.9a: Step Four towards Development of the Instructional Model

Summary of the Requirements for this Model

This model works well when the teachers are properly trained on how to prepare for teaching of Physics well. Teachers should have good mastery of the Physics subject matter. It also assumes availability of ICT resources. Teachers should be trained on the TPACK model for effective integration of technology in the learning process. They should also be able to prepare ICT integrated schemes of work. This is followed by preparation of ICT integrated lesson plans. These two documents are key to the success of using this model. It is also important to note that constructivist - based approaches of teaching Physics are a key component while using this model. Teachers of Physics should use constructivist - based approaches coupled with ICTs during the teaching and learning process. While teaching, Physics teachers should ensure that they effectively integrate ICTs in the learning process. The TPACK model is highly recommended for use when preparing to teach with technology. The teaching and learning resources should be selected carefully. The content used for instructional purposes should have
quality animations. The quality of the animations should be determined by ascertaining whether they are relevant, interesting and interactive. The images used within the animations should make proper use of colour and they should also be proportional. According to Mayer & Moreno (2002), appropriate, suitable and on-time use of animation supports the learning process. According to Mayer’s cognitive theory (2002) knowledge is represented and manipulated through two cognitive channels: visual-pictorial and auditory-verbal. Animations are a combination of the two channels. Following the definition of multimedia, the learners who study with the use of animations, apply three learning styles: visual, auditory and kinesthetic and use three senses: seeing, hearing, and touching. Studies have shown that usage of multi-senses for the construction of knowledge, promotes meaningful learning (Barak, et al., 2011).

Moreover, Physics teachers should be aware of what they expose learners to avoid overburdening them with unnecessary cognitive load while teaching using animations. Animations to be used while using the Planning, Facilitating and Learning with Animations (PFLA) instructional model should be well designed to avoid burdening learners with unnecessary cognitive load. Turel (2015) indicates that all aspects of interactive multimedia require the designers and developers to consider the requirements of cognitive load theory which puts emphasis on how essential it is to design every multimedia element effectively and efficiently. It is envisaged that when this model is applied while teaching Physics, learners’ performance in Physics will improve.
Conclusion

The instructional model for effective use of ICT with animations included in IDC should emphasize on preparing adequately before teaching. Physics teachers should plan to use enquiry based approaches while teaching. They should be inducted to facilitate using the TPACK model which gives the framework required to ensure technology is properly integrated during the instructional process. The ICTs used should be rich enough to create interest and motivate to learn Physics. This will increase the Academic Learning Time (ALT) of the learners and in the process they will conceptualize Physics concepts better. This will eventually lead to high performance in Physics.

![Figure 4.9b: Summary PFLA Model](image)

Figure 4.9b: Summary PFLA Model
CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This study mainly focused on the effect of animations embedded in Physics Interactive Digital Content (IDC) on performance of secondary learners in Physics. It adopted a quasi-experimental research design. There was a Control Group (CG) and an Experimental Group (EG). In this chapter, conclusions emanating from the findings of the study have been drawn and recommendations made. Suggestions for further research have also been stated.

5.1 Summary of the Study

The study brought out the key findings which were mainly presented in the previous chapter. Analysed data from the teachers’ and learners’ questionnaires in both qualitative and quantitative formats were also presented. Analysis of the collected data was done as per the objectives of the study. Analysis of the tests administered to learners in both study groups assisted in establishing the effect of animations embedded in the Physics IDC to a great extent.

The first objective for this study was to determine the influence of instructional values inculcated by animations embedded in Physics IDC on performance of learners in Physics. The findings from this study have revealed that animations embedded in Physics IDC were interesting to the learners and this motivated them to study Physics. Their Academic Learning Time (ALT) increased and they spent more time studying the subject. Quality animations have an effect in the teaching and learning process. The effect of their increased ALT was demonstrated through improved performance of learners in Physics.
The second objective was to determine the effect of animations on the concentration span of learners while learning Physics. Data collected using OS, teachers’ and learners’ questionnaires revealed that learners in the EG concentrated more during the learning process. The concentration span of learners was extended and they were more interested during the learning process. This also led to increased ALT and hence better performance in Physics by learners in the EG.

The third objective sought to find out if animations enhance conceptual understanding of text within the Physics IDC. Findings of this study have shown that animations embedded on Physics IDC assisted learners to conceptualise the text within the IDC better. This was demonstrated through their abilities to perform well in the tests administered and also through their responses collected using Physics teachers’ questionnaires and Physics learners’ questionnaires.

The findings made during this study have shown that there was improved performance in Physics especially by learners in the EG. Animations have visuals which are interesting to learners. The interesting visuals motivate learners to spend more time learning Physics and this increases their ALT. This eventually leads to improved learners’ performance in Physics.

5.2 Conclusions of the Study

The following conclusions are made from this study:

a) Interactive Digital Content (IDC) with quality animations is more interesting to learners and it engages them fully hence motivating them to study the subject more. This was
observed during the study. Learners from the experimental schools spent more ALT interacting and learning with the content.

b) Physics IDC with animations is interesting to the learners and it engages them fully hence extending their concentration span. This was also observed during the study. Learners from the experimental schools spent more learning with IDC which led to improved performance.

c) Physics IDC with animations helps learners to understand abstract concepts in Physics better. Physics teachers and learners were able to reveal this through different items in their respective questionnaires. The improved performance in Physics by learners who were taught using IDC with animations is also enough evidence that animations assisted learners to conceptualise Physics subject matter better.

d) Quality animations have an effect in the teaching and learning process. A comparison of the mean scores posted by learners from the control and experimental groups was able to bring the difference out. The significance of the difference in the two means was tested using t-test and the results showed that the difference between the two means was significant. Findings from the study have shown that learners who are taught using IDC with quality animations perform better than those who use IDC without animations.
5.4 Recommendations for Action

The findings made during this study have led to the following recommendations:

a) Physics educators should plan for and use IDC with animations during the instructional process. Use of Physics IDC with animations elicits a lot of interest among learners and motivates them to spend more time studying the subject.

b) Developers of IDC should ensure that their IDC is developed with adequate quality animations to assist learners in understanding the abstract aspects of Physics content. This will also cater for learners with different learning styles.

c) Ministry of Education through the Quality Assurance Directorate should review the policy on instructional materials with a view of guiding Physics educators on the type of instructional resources to use while teaching Physics. The resources to use should be inclusive of Physics IDC with animations.

d) Teacher educators need to train teachers on how to use Physics IDC with animations during the instructional process. This should be done during pre – service training of teachers. This training will inform teacher trainees on how to effectively use Physics IDC for improved performance in Physics.

e) School administrators need to be sensitized on the role played by Physics IDC with animations. This will create awareness and they will be able to understand the importance of IDC in the learning process.
5.5 Suggestions for Further Research

This study did not consider observing the effect of other multimedia elements like videos, audio, illustrations and photographs. Videos are audio-visual teaching aids and their effect needs to be established as well. They assist learners in formation of schemas which aid in storage of knowledge acquired during the learning process. Few studies if any have been conducted to determine the effect of the videos embedded in IDC in Kenya and this is an area where further research can be conducted.

The same case applies to the other multimedia elements embedded in the IDC including audio, illustrations and photographs. It should be noted that audio can be used to create narrations which assist learners with visual impairment to consume digital content like regular learners.

Another study should be conducted to establish whether audio, video and images have effect on performance of the Physics learners as well. It is worth noting that this study was conducted in only four schools in Nairobi County. There will be need therefore to conduct a similar study in other Kenyan counties. There is also need to conduct a study to establish the effect of animations embedded in other IDC in subjects such as Chemistry, Biology and Mathematics on performance of learners.
References


National Survey, Centre for Social Organization of Schools. The John Hopkins University.


146
The International Review of Research in Open and Distance Learning, 13 (2).


https://doi.org/10.1023/A:1008894006039


APPENDIX I: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. JOSEPH MUTETI WAMBUA
of KENYATTA UNIVERSITY, 30231-100
Nairobi, has been permitted to conduct
research in Nairobi County

on the topic: THE EFFECT OF
ANIMATIONS IN E-LEARNING MATERIALS
ON PHYSICS PERFORMANCE AMONG
SECONDARY SCHOOL STUDENTS IN
NAIROBI CITY COUNTY, KENYA.

for the period ending:
28th July, 2018

Applicant's Signature

Director General
National Commission for Science,
Technology & Innovation
APPENDIX II: Research authorization letter from NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Tel: 254-20-2213471, 2215639, 2214061, 2214040
Fax: 254-20-318215, 318249
Email: dig@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote Ref No. NACOSTI/P/17/98962/18467

Date: 31st July, 2017

Joseph Muteti Wambua
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on “The effect of animations in E-Learning materials on physics performance among secondary school students in Nairobi City County, Kenya,” I am pleased to inform you that you have been authorized to undertake research in Nairobi County for the period ending 28th July, 2018.

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

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

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.
## APPENDIX III: List of public secondary schools in Nairobi County

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<th>S/NO</th>
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<th>SCHOOL NAME</th>
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<td>KAMITI SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>50</td>
<td>20408001</td>
<td>KAYOLE SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>51</td>
<td>20408007</td>
<td>EMBAKASI GIRLS SECONDARY SCHOOL</td>
<td>Girls Boarding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>----------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>52.</td>
<td>20408014</td>
<td>PETER KIBUKOSYA SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>53.</td>
<td>20408015</td>
<td>KAYOLE SOUTH SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>54.</td>
<td>20409001</td>
<td>DANDORA SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>55.</td>
<td>20409002</td>
<td>MUHURI MUCHIRI BOYS HIGH SCHOOL</td>
<td>Boys Boarding</td>
</tr>
<tr>
<td>56.</td>
<td>20409003</td>
<td>HON. DR. MWENJE SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>57.</td>
<td>20409004</td>
<td>USHIRIKA SECONDARY SCHOOL</td>
<td>Mixed Day</td>
</tr>
<tr>
<td>58.</td>
<td>20409005</td>
<td>JEHova JIRE SECONDARY SCHOOL</td>
<td>Mixed Boarding</td>
</tr>
<tr>
<td>59.</td>
<td>20409006</td>
<td>DRUMVALE SECONDARY SCHOOL</td>
<td>Mixed Boarding</td>
</tr>
<tr>
<td>60.</td>
<td>20409007</td>
<td>ST. GEORGE ATHI SECONDARY SCHOOL</td>
<td>Mixed Boarding</td>
</tr>
</tbody>
</table>

*Source: Ministry of Education, Kenya (2010).*
APPENDIX IV: List of ESP secondary schools in Nairobi County.

<table>
<thead>
<tr>
<th>S/NO.</th>
<th>NAME OF SCHOOL</th>
<th>CONSTITUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mutuini High School</td>
<td>Dagoretti</td>
</tr>
<tr>
<td>2.</td>
<td>Dagoretti Mixed Secondary School</td>
<td>Dagoretti</td>
</tr>
<tr>
<td>5.</td>
<td>Dagoretti High School</td>
<td>Dagoretti</td>
</tr>
<tr>
<td>6.</td>
<td>Mwangaza Secondary School</td>
<td>Embakasi</td>
</tr>
<tr>
<td>7.</td>
<td>Kayole South Secondary School</td>
<td>Embakasi</td>
</tr>
<tr>
<td>8.</td>
<td>Dandora Secondary School</td>
<td>Embakasi</td>
</tr>
<tr>
<td>9.</td>
<td>Ruai Girls</td>
<td>Embakasi</td>
</tr>
<tr>
<td>10.</td>
<td>Jehova Jire Secondary</td>
<td>Embakasi</td>
</tr>
<tr>
<td>11.</td>
<td>Maina Wanjigi Secondary School</td>
<td>Kamukunji</td>
</tr>
<tr>
<td>12.</td>
<td>Uhuru Secondary School</td>
<td>Kamukunji</td>
</tr>
<tr>
<td>13.</td>
<td>Eastleigh Secondary School</td>
<td>Kamukunji</td>
</tr>
<tr>
<td>15.</td>
<td>Our Lady of Mercy - Shauri Moyo</td>
<td>Kamukunji</td>
</tr>
<tr>
<td>16.</td>
<td>Baba Ndogo Secondary School</td>
<td>Kasarani</td>
</tr>
<tr>
<td>17.</td>
<td>Kahawa Garrison Secondary School</td>
<td>Kasarani</td>
</tr>
<tr>
<td>18.</td>
<td>Kasarani Our Lady of Fatima</td>
<td>Kasarani</td>
</tr>
<tr>
<td>19.</td>
<td>Kamiti Secondary School</td>
<td>Kasarani</td>
</tr>
</tbody>
</table>
22. Olympic Secondary School  Langata
23. Langata Barracks Secondary School  Langata
24. Raila Education Centre  Langata
27. Ofafa Jericho Secondary School  Makandara
28. Nile Road Secondary School  Makandara
29. Makongeni Mixed Secondary School  Makandara
30. Our Lady of Mercy South B Secondary School  Makandara
31. Muranga Road Boys Secondary  Starehe
32. C.G.H.U. Mixed Day Secondary  Starehe
33. St. Teresa’s Girls Day Sec.  Starehe
34. Pumwani Boys Secondary  Starehe
35. Ndururuno Mixed Secondary  Starehe
36. Hospital Hill High School  Westlands
37. State House Girls  Westlands
38. Kangemi High School  Westlands
39. Parklands Arya Girls High School  Westlands
40. St. George’s Girls School  Westlands

APPENDIX V: Physics Assessment Test (Pre-Test)

FORM THREE PHYSICS  

STUDENT’S NAME…………………………………..ADM NO……………………

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

Attempt all questions

1. (a) Define refractive index.(1mark)

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

(b) The critical angle of a certain material medium is 43.2º. Determine the refractive index of the material. (2 marks)

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

2. Figure 1 shows a ray of light incident on water-kerosene interface.

![Figure 1]

Kerosene

Water

Figure 1
State which one of the two liquids has a higher absolute refractive index (1 mark).

3. A trolley of mass 0.5kg moving with a velocity of 1.2ms$^{-1}$ collides inelastically with a second trolley of mass 1.5kg moving in the same direction with a velocity of 0.2ms$^{-1}$.
   a) What is an inelastic collision? (1 mark)

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

b) Determine the velocity of the trolleys after collision.(2 marks)

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

4. A body of mass 25 kg moving with uniform acceleration has an initial momentum of 60 kg m/s and after 10 seconds the momentum is 90 kg m/s. What is the acceleration of the body? (2mks)

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
5. A footballer kicks a ball of mass 0.6 kg initially at rest using a force of 720N. If the foot was in contact with the ball for 0.1 seconds, what was the take of speed of the ball? (3 marks)

6. A small bright object O lies at the bottom of a beaker containing water of depth $h$ cm. A convex lens of focal length 15cm is held at the surface of water. The lens forms an image of O at 45cm from the surface of water.

Taking the refractive index of water to be $4/3$, determine:

(a)

i) The apparent depth of the object (2mks)
ii) The real depth $h$, of the object (2mks).

\(\textbf{(b)}\) A ray of light is incident at right angles to the face AB, of a right angled isosceles prism of refractive index 1.6 as shown in Figure 3.

If the prism is surrounded by a liquid of refractive index 1.40, determine:

(i) The angle of incidence on the face BC. (1 marks)

(ii) The angle of refraction on the face BC. (3 marks)
APPENDIX VI: Physics Assessment Test Marking Scheme (Pre – Test)

1. (a) Refractive index is ratio of sine of angle of incidence to the sine of angle of refraction for a given pair of media. ✓

(b) \[ n = \frac{1}{\sin C} \]

\[ = \frac{1}{\sin 43.2°} \] ✓

\[ = 1.4608 \]

\[ = 1.46 \] ✓ (2 marks)

2. Water √ (1 mark)

3. (a) A collision in which objects combine / fuse, losing kinetic energy in the process (1 mark)

(b) Final momentum = Initial momentum

\[ (0.5 + 1.5) \ V = (0.5 \times 1.2) + (1.5 \times 0.2) \] (1 mark)

\[ 2.0V = 0.6 + 0.3 \]

\[ 2.0V = 0.9 \]

\[ V = 0.45 \text{ m/s} \] (1 mark)

4. \[ Ft = mv - mu \]

Mv= 60 kg m/s

T = 10s

\[ F = 90 - 60 = 3N \]

\[ 10 \]

But \[ F = ma \]

\[ a = \frac{f}{m} = \frac{3}{25} = 0.12 \text{ m/s} \]
a = 0.12m/s²

5. \( \text{Ft} = \text{m} \ (v - u) \);

\[ 720 \times 0.1 = 0.6 \ (v - 0) ; \]

\[ V = 720 \times 0.1 \]

\[ 0.6 \]

\[ V = 120 \text{ m/s} \]

6 (a) (i) Taking the refractive index of water to be 4/3, determine:

(i) the apparent depth of the object (2mks)

\[ \frac{1}{u} + \frac{1}{v} = \frac{1}{f} \]

\[ \frac{1}{u} + \frac{1}{45} = \frac{1}{15} \]

\[ \frac{1}{u} = \frac{1}{15} - \frac{1}{45} = \frac{2}{45} \]

\[ U = \frac{45}{2} = 22.5 \text{ cm} \]

Apparent depth = 22.5 cm

(ii) the real depth \( h \), of the object (2mks)

\[ n = \frac{\text{real depth}}{\text{apparent depth}} \]

Real depth = \( n \times \text{AD} \)

\[ = \frac{4}{3} \times \frac{45}{2} \]

\[ = 15 \times 2 \]

\[ = 30 \text{ cm}. \]

b. (i) If the prism is surrounded by a liquid of refractive index 1.40, determine:
The angle of incidence on the face BC. (1mk)

\[ i = 45^\circ \]

(iii) The angle of refraction on the face BC. (3mks)

\[ \frac{n_2}{n_1} = \frac{1.4}{1.6} = \frac{\sin 45^\circ}{\sin r} \]

\[ \sin r = \frac{1.6 \sin 45^\circ}{1.4} \]

\[ = 0.742 \]

\[ r = 53.0 \]
APPENDIX VII: Physics Assessment Test (Post-Test)

FORM THREE PHYSICS

TIME: 1 HOUR 20 MINUTES

STUDENT’S NAME…………………………………………ADM NO……………………

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

Attempt all questions.

1. State Newton’s first law of motion (1mk).

2. A trolley of mass 0.5kg moving with a velocity of 1.2ms\(^{-1}\) collides inelastically with a second trolley of mass 1.5kg moving in the same direction with a velocity of 0.2ms\(^{-1}\).

   (a) What is an inelastic collision? (1 mark)

   ________________________________________________________________
   ________________________________________________________________

   (b) Determine the velocity of the trolleys after collision. (2 marks)

   ________________________________________________________________
   ________________________________________________________________

3. A body of mass 25 kg moving with uniform acceleration has an initial momentum of 60 kg m/s and after 10 seconds the momentum is 90 kg m/s. What is the acceleration of the body? (2mks)

   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
4. A footballer kicks a ball of mass 0.6 kg initially at rest using a force of 720N. If the foot was in contact with the ball for 0.1 seconds, what was the take of speed of the ball?
(3 marks)

5(a) A lawn tennis ball is thrown such that it hits a wall perpendicularly at a speed of 6.5m/s as shown in figure 1.

The ball has a mass of 50g and it is in contact with the wall for 0.02s.
(i) What is meant by impulse?  (1 mark)

(ii) Find how much force is applied to the wall by the ball (3 marks)

(iii) How much deceleration does the ball experience? (2 marks)

(iv) Determine the change in momentum of the ball. (2 marks)

(v) Giving your reasons state the type of collision that the ball undergoes. (2 marks)

(b) Basing your argument on Newton’s second law, explain why the athletes for high jump land on a thick soft mattress and not on a hard ground. (1 mark)
APPENDIX VIII: Physics Assessment Test Marking Scheme (Post – Test)

1. If a body is at rest it remains at rest or if it is in motion it moves with uniform velocity until it is acted on by a resultant force. (1 mark)

2. (a) A collision in which objects combine / fuse, losing kinetic energy in the process (1 mark)

(b) Final momentum = Initial momentum

\[ (0.5 + 1.5) \times V = (0.5 \times 1.2) + (1.5 \times 0.2) \] (1 mark)

\[ 2.0V = 0.6 + 0.3 \]

\[ 2.0V = 0.9 \]

\[ V = 0.45 \text{ m/s} \] (1 mark)

3. \( Ft = mv - mu \)

\( Mv = 60 \text{ kg m/s} \)

\( T = 10 \text{s} \)

\[ F = 90 - 60 = 3 \text{N} \]

\[ \frac{10}{1} \]

But \( F = ma \)

\[ a = \frac{f}{m} = \frac{3}{25} = 0.12 \text{m/s} \]

\[ a = 0.12 \text{m/s}^2 \]

4. \( Ft = m(v - u) \); 

\[ 720 \times 0.1 = 0.6 \times (v - 0) ; \]

\[ V = \frac{720 \times 0.1}{0.6} \]

\[ V = 120 \text{ m/s} \]

170
5(a) (i) Effect produced when a large force acts on a body for a short time  

(ii) \[ F = \frac{m_f - m_i}{r} \]  
\[ = \frac{0.05(-6.5 - 6.5)}{0.02} \]  
\[ = \frac{-0.65}{0.02} \]  
\[ = -32.5 \text{N} \]  

\[ F = ma \]

(iii) 
-32.5 = 0.05 x a  
\[ a = -650 \text{ms}^{-2} \] (deceleration)  

change in momentum = Ft  

(iv) 
\[ -32.5 \times 0.02 = 0.65 \text{Ns} \]  

Elastic collision  

(v) The ball is in contact with the wall for very short time before they separate  

b) The athlete experience retarding force for some time before coming to rest.  
\[ \checkmark \] This duration reduces the impact of the ground on the athlete when
they finally come into contact. On hard ground the athlete would abruptly come to rest and thus the duration of the impact will be very short thus the ground applies a lot of impulsive force on the athlete, injuring him extensively.
APPENDIX IX: Questionnaire for Physics learners

Introduction

The researcher is carrying out a study on some topics in the Physics interactive digital content developed for Form Three learners. To achieve the objectives of the study, views and opinions will be sought from learners who will use it. You are therefore kindly requested to respond to the following items by filling in the blank spaces or ticking the appropriate boxes. The information you provide will be held in confidence and used for purposes of this study only.

Section A: General Information

1. Sex
   - Male □   - Female □

2. Name of school: …...........................................

3. School Category (Tick appropriately)
   i. National □   Extra-county □   County □   Sub – county □
      Others (Specify) ...........................................
   ii. Girls □   Boys □   Mixed □

Section B

Table QL1 has two Physics topics in the Form Three Physics syllabus which are packaged in the interactive digital content. To what extent did the content help you in understanding the listed topics? (Indicate by ticking in the appropriate level).

Scale:

1. - Not at all
2. - Made a slight difference
3. - To a great extent
Table QL1: Learner’s opinions on their level of understanding

<table>
<thead>
<tr>
<th>Topic</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refraction of light</td>
<td>1 2 3</td>
</tr>
<tr>
<td>Newton’s laws of motion</td>
<td>1 2 3</td>
</tr>
</tbody>
</table>

Section C

In your own opinion, how is the interactive Physics content as compared to the Physics textbooks you use for learning. State your level of agreement with the statements given in table QL2 by ticking in the appropriate box guided by the scale below.

Scale:

SA - Strongly agree
A - Agree
NS – Not sure
D – Disagree
SD – Strongly Disagree
Table QL2: Learners’ ratings on the interactive digital content

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>The interactive content is more interesting</td>
<td></td>
</tr>
<tr>
<td>The interactive content motivates one to read more</td>
<td></td>
</tr>
<tr>
<td>Physics interactive digital content encourages one to concentrate on learning for a longer period of time</td>
<td></td>
</tr>
<tr>
<td>Physics interactive digital content has some features which help one to understand some concepts better</td>
<td></td>
</tr>
<tr>
<td>Physics interactive digital content makes learning more fun</td>
<td></td>
</tr>
<tr>
<td>Physics interactive digital content engages the learner fully (interactive)</td>
<td></td>
</tr>
<tr>
<td>Physics interactive digital content helps one in visualizing abstract ideas</td>
<td></td>
</tr>
<tr>
<td>The animations in Physics interactive digital content are relevant to the text</td>
<td></td>
</tr>
</tbody>
</table>

Additional comments about your experience with Physics interactive digital content

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
APPENDIX X: Questionnaire for Physics teachers

Introduction

The researcher is carrying out a study on some topics in the Physics interactive digital content developed for Form Three. To achieve the objectives of the study, views and opinions are required from curriculum implementers. You are therefore kindly requested to respond to the following items by filling in the blank spaces or ticking the appropriate boxes. The information you provide will be held in confidence and used only for purposes of the study.

1. Name of school: ..................................................
2. Name of county: .............................................
3. Gender: Male □ Female □

4. Table QT1 has a list of the animations used for the purposes of helping the user of the content understand some Physics concepts, laws, principles and theories. By ticking in the appropriate box, indicate your level of agreement on the relevance of the animation to the text it is supposed to help the users understand.

(Use the key: SA=’Strongly agree’, A=’Agree’, NS=’Not sure’, D=’Disagree’ and SD=’Strongly disagree’ and indicate your level of agreement by ticking in the appropriate box)

Table QT1: Teachers’ opinions on the relevance of animations used with respect to their ability to demystify the respective Physics concepts, laws, theories and principles.

<table>
<thead>
<tr>
<th>Animation serial number</th>
<th>Level of agreement on relevance of the animation to text</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
</tr>
<tr>
<td>P31001</td>
<td></td>
</tr>
<tr>
<td>P31002</td>
<td></td>
</tr>
<tr>
<td>P31003</td>
<td></td>
</tr>
<tr>
<td>P31004</td>
<td></td>
</tr>
<tr>
<td>P31005</td>
<td></td>
</tr>
<tr>
<td>P31006</td>
<td></td>
</tr>
<tr>
<td>Animation serial number</td>
<td>Description of the animation</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>P31001</td>
<td>Animation illustrating definition of momentum</td>
</tr>
<tr>
<td>P31002</td>
<td>Animation illustrating and simulating Newton’s second law of motion</td>
</tr>
<tr>
<td>P31003</td>
<td>Impulse</td>
</tr>
<tr>
<td>P31004</td>
<td>Animation illustrating Newton’s third law of motion</td>
</tr>
<tr>
<td>P31005</td>
<td>Animation illustrating Recoil velocity</td>
</tr>
<tr>
<td>P31006</td>
<td>Animation illustrating and simulating collisions (Combining elastic and inelastic)</td>
</tr>
<tr>
<td>P31007</td>
<td>Animation illustrating and simulating elastic collisions</td>
</tr>
<tr>
<td>P31008</td>
<td>Animation illustrating and simulating inelastic collisions</td>
</tr>
<tr>
<td>P31009</td>
<td>Animation illustrating and simulating law of conservation of linear momentum</td>
</tr>
<tr>
<td>P31010</td>
<td>Animation illustrating and simulating fluid friction (Viscosity)</td>
</tr>
<tr>
<td>P32001</td>
<td>Animation illustrating and explaining refraction</td>
</tr>
</tbody>
</table>
P32002  Animation illustrating and simulating refraction
P32003  Animation illustrating and simulating critical angle
P32004  Animation illustrating and simulating total internal reflection
P32005  Animation illustrating and simulating the prism periscope
P32006  Animation illustrating and simulating the functioning of the optic fibre
P32007  Animation illustrating and simulating dispersion of light

5. In your own opinion, how is the interactive Physics content as compared to the Physics textbooks you use for teaching and learning purposes. State your level of agreement with the statements given in Table QT2 by ticking in the appropriate box guided by the scale below.

Scale:

SA - Strongly agree
A - Agree
NS – Not sure
D – Disagree
SD – Strongly Disagree

Table QT2: Teachers’ ratings on the interactive digital content

<table>
<thead>
<tr>
<th>Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
</tr>
<tr>
<td>The interactive content is interesting</td>
<td></td>
</tr>
<tr>
<td>The interactive content motivates one to read more</td>
<td></td>
</tr>
<tr>
<td>It encourages one to concentrate on learning for a longer period of time</td>
<td></td>
</tr>
<tr>
<td>It has some features which help one to understand some concepts better</td>
<td></td>
</tr>
<tr>
<td>It makes learning fun</td>
<td></td>
</tr>
</tbody>
</table>
It engages the learner fully (interactive)

It helps one in visualizing abstract ideas

The animations in the content are relevant to the text

Additional comments on Physics interactive digital content

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

THANK YOU
APPENDIX XI: Observation Schedule used to observe Physics Lessons

PART A: PERSONAL DATA

School .................................................Class..........................

Teacher's teaching experience..............................

Academic qualifications............................................Date...........

PART B: ASSESSMENT OF TEACHING AND LEARNING PROCESS

The rating on the statements given in the table are guided by the scale below

(Scale: 1-not at all; 2-a little, 3-fairly adequate, 4-adequately, 5-a great deal)

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners interacted with the interactive digital content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners used interactive digital content for learning purposes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners remained attentive throughout the time they were using the content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners appeared to be interested while using the interactive digital content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners were able to answer the teacher’s questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners asked the teacher questions while using the digital content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learners made correct observations and conclusions after using the interactive digital content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Additional observations on the teaching and learning process
APPENDIX XII: A map of Kenya showing the location of Nairobi County

COUNTIES OF KENYA

KEY
1. NAIROBI
2. KIAMBU
3. MURANGA
4. KIRINYAGA
5. NYERI
6. NYANDARUA
7. BOMET
8. KERICHO
9. TRANS NZOLA
10. UASIN GISHU
11. ELGEYO-MARAKWET
12. NANDI
13. BUNGOMA
14. BUSIA
15. KAKAMEGA
16. VEIMA
17. SIAYA
18. MIGORI
19. KISII
20. KISUMU
21. NYAMIRA
22. HOMA BAY