INTEGRATION OF ICT IN THE TEACHING AND LEARNING OF GENETICS IN SELECTED SECONDARY SCHOOLS IN KITWE DISTRICT, ZAMBIA

By

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A dissertation submitted to the University of Zambia, School of Education, in partial fulfilment for the requirements for the award of the Degree of Master of Education in Science Education

THE UNIVERSITY OF ZAMBIA

LUSAKA

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DECLARATION

I, **Gregory Chileshe**, hereby declare that this dissertation is my own and that it has not been previously submitted for the ward of a degree at the University of Zambia or any other university.

Signed (Candidate): ………………………………. Date: ……………………………2019

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APPROVAL

This dissertation by **Gregory Chileshe** is approved as fulfilment for the award of the Degree of Master of Education in Biology Education by the University of Zambia.

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DEDICATION

This work is dedicated to my wife Mrs. Juliet Namwawa Chileshe (Bana Bukata), my beloved Son, Bukata Chengelo Chileshe, my parents (Mr. and Mrs. Chileshe), my young brother (Bwalya chileshe), my sisters, and most of all my beloved late Elder sister Tercy Mulenga Chileshe whose positive support, encouragement and sheer will towards my studies remain inspirational.

ABSTRACT

The integration of Information Communication Technology (ICT) in the teaching and learning of genetics has the potential to dramatically transform the teaching and learning process The study investigated the integration of ICT in the teaching and learning of genetics at two Secondary Schools in Kitwe, District. The purpose of the study was to find out the effects of integrating ICT on the performance, and attitudes of pupils and teachers in genetics in two selected secondary schools in Kitwe district when used as a supplement to traditional teaching and learning approaches.

The study used a mixed method approach (concurrent triangulation design). The study involved the use of: interviews, focus group discussions, questionnaires, and pre-test and post-test methods for collecting qualitative and quantitative data. The 2 X 2 design analysis was used as guide to analyse pupils' pretest and posttest test, and pupil questionnaires for quantitative data, while data from focus group, and face to face interviews were thematically analysed.

The findings showed that there was a significant increase in performance in genetics when ICT tools were used in the teaching and learning of genetics. Results also showed that there was significance difference in genetics performance between gender and group names (experimental groups and control groups). However, there was no significance difference in genetics performance among different age groups of pupils. Both pupils and teachers' showed positive attitude towards the use of ICT in genetics with average attitude mean scores ranging between 4.5 to 5.5. The results also showed that ICT knowledge and skills, inadequate ICT infrastructure, lack of ICT training and poor access to ICT negatively affected teachers and pupil's attitudes towards the use of ICTs in the teaching and learning of genetics.

The study concluded that ICT tools improves pupil's performance in genetics when they are used as enhancement to traditional teaching and learning methods. Furthermore, the use of ICT tools in the teaching and learning of genetics were found to be excellent pedagogical tools that can be used to bridge up gender disparities in genetics and increase performance across gender. The study also established that pupils in the experimental groups performed better than pupils in the control groups despite their age group differences. Thus, the use of ICTs was found helpful in sorting out age-group disparity in pupil's performance in genetics. The study further established that both teachers and pupils had positive attitude towards that use of ICT in the teaching and learning of genetics. However, other factors such as teachers and pupil's skills and knowledge of ICTs, ICT infrastructure, ICT training and technical support were found to be negatively affecting their attitudes towards ICT use in the teaching and learning of genetics. Finally, teachers and pupils recommended that ICTs were resourceful tools that motivated and increased pupil's performance in genetics when they were used in the teaching and learning process. Based on the findings, it was recommended that teachers of biology should integrate ICT tools in the teaching and learning of genetics.

Key words: ICT, integration, learning, teaching, attitude, performance, genetics

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OPERATIONAL DEFINIATION OF TERMS

Information and Communication Technology: ICTs refers to computers and computer accessories (such as projectors), videos, Microsoft excel and Gene X simulation software that were used in the teaching and learning of genetics.

Attitude: Any particular behaviour, either positive or negative towards genetics or ICT tools that may affect pupils or teachers use of ICTs in the teaching and learning of genetics.

Genetics: the study of heredity and the variation of inherited characteristics (traits) on chromosomes.

Learning: any knowledge, attitudes and process skills that were acquired through the pupils' experiences throughout the study.

Teaching: to impart knowledge, attitudes and process skills in pupils through their experiences in the learning environment.

ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
C_1 and C_2	Control groups 1 and 2 respectively
CDC	Curriculum Development Centre
df	Degrees of freedom
DNA	Deoxyribonucleic acid
E_1 and E_2	Experimental groups 1 and 2 respectively
ECZ	Examination Council of Zambia
f	Frequency
F	Levene's test
ICT	Information Communication Technology
M	Mean
MD	Mean difference
MOE	Ministry of Education
MR	Mean ranking
N	Number
NDP	National Development Plan
η	Eta
η^2	Eta square
Q	Pretest/post-test
SD	Standard deviation
SK	Significant ranking
SPSS	Statistical Package for Social Science
T	t-Test
UNESCO	United Nation Education Scientific and Cultural Organisation
X	Treatment (ICT tools intervention)
ZPD	Zone of Proximal Development

CHAPTER ONE: INTRODUCTION

1.1. Overview

This chapter contained the background of the study, a statement of the problem, purpose of the study, research objectives, research questions and hypothesises. It further contains the scope of the study, a theoretical framework, the significance of the study, delimitations and operational definitions of terms.

1.2. Background

1.2.1. Factors affecting performance and attitudes of pupils and teachers in Biology (genetics) topics

Biology is one of the most important subjects in every human society and provide entry to many natural science career pathways (Examinations Council of Zambia [ECZ], 2017). Thus, learning and understanding of the content, process skills and values in biology will provide a strong foundation for the development of individual and nation at large. However, it is saddening to note that the average pass mean score performance in biology at grade 12 has remained stagnant at below 40% as shown in Figure 1.2. below.

Annual pass rate mean score performance of grade 12 candidates in biology from 2013 to 2016

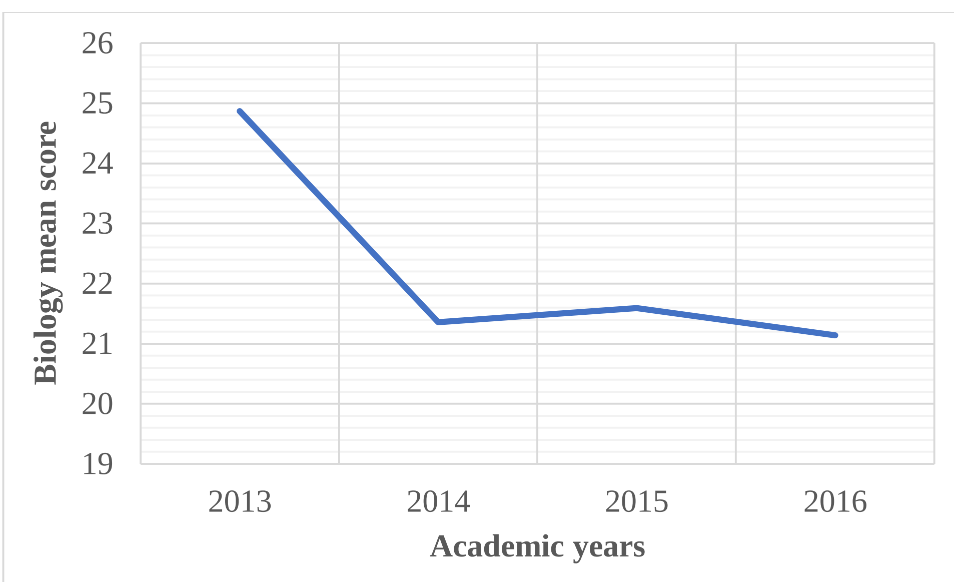

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Figure. 1.2. Annual mean scores performance in biology from 2013 to 2016

Source: ECZ (2017)

Students' difficulties in learning biology have been studied by various researchers across the world (Johnstone and Mahmoud; 1980, Finley *et al*, 1982; Tolman, 1982; Anderson *et al*, 1990; Seymour and Longdon, 1991; Jennison and Reiss, 1991; Lazarowitz and Penso, 1992). Many concepts and topics in biology, including water transport in plants, protein synthesis, respiration and photosynthesis, gaseous exchange, energy, cells, mitosis and meiosis, organs, physiological processes, hormonal regulations, oxygen transport, genetics, Mendelian genetics, genetic engineering and the central nervous system are perceived as difficult to learn by the secondary school pupil (Bahar *et al*, 1999). Tekkaya *et al* (2001) also found that hormones, genes and chromosomes, mitosis and meiosis, the nervous system and Mendelian genetics were considered difficult concepts by secondary school students. Experiencing difficulties in so many topics in biology negatively affects students' motivation and achievement (Ozcan, 2003).

According to Çimer (2011) there are five topics that students find most difficult to learn: Matter cycle, endocrine system and hormones, aerobic respirations, cell division including genes and chromosomes.

It can be seen from the literature that genetics, genetic engineering, genes and chromosomes and cell division (mitosis and meiosis) continue to recur among the topics that are viewed as difficult to teach and learn across the global. Çimer (2011) further stressed that the main reasons for the learning difficulties were the nature of the topic (the abstract levels of genetics), teachers' styles of teaching, students' learning and studying habits, students' negatives feelings and attitudes towards the topics and lack of resources.

In Zambia, genetics covers the following aspects: variations, cell division and chromosome, inheritance and mutation (Curriculum Development Centre [CDC], 2013). Genetics is one of the topics in biology at senior secondary level that is rated as one of the most difficult topics in the biology syllabus to teach and learn by both teachers and learners respectively (Haambokoma, 2007; Haambokoma *et al*, 2002; Haambokoma and Mwale, 1998; Ministry of Education [Moe], 1994). According to the ECZ (2013, 2014, 2015, 2016) annual examination review reports for Biological Sciences, genetics and numerical questions still continue to perform poorly at grade 12 national examinations. The Chief's examiners' report for biology theory papers for 2016 indicate that candidates have difficulties answering questions on genetics in the final examinations (ECZ, 2016).

The study by Chifwa (2015) revealed that 72% of teachers of biology in Kitwe District used the lecture method to teach genetics while about 28% used group work. The study further revealed that all the teachers that were observed used question and answer technique, and asked low order questions during the lessons. In most cases, the topic was not taught asserting that the time allocated to biology was inadequate (Chifwa, 2015). Other research studies also revealed that teachers do not use teaching and learning aids, lack appropriate teaching and learning aids, do not give homework to learners and conduct practical work when teaching genetics (Chifwa, 2015; Haambokoma, 2007; Musonda, 2013).

To overcome these difficulties and making teaching and learning of genetics interesting, there is need to adopt and integrate new technological ways in the teaching and learning of genetics, such as:- the use of visual materials, teaching through practical work (using ICT resources), reducing the content of genetics by using various teaching techniques, teaching genetics by connecting the topic to our daily lives, making genetics learning interesting, and increasing the diversity of genetics questions in classroom assessments and in examination papers. Furthermore, increasing courses in genetics at tertiary level and engaging in genetics researches so as to boost the role models in genetics. Previous research studies have shown that teachers' use of using visual materials like pictures, posters, models, and computers in the lessons, were found to be effective in making the lessons attractive and interesting for students (Mistler-Jackson and Songer, 2000; Paul and Fernandez, 2000).

Cyrs (1997) and Çimer (2004, 2007) indicated that students remember best those concepts that are presented in a way related to their sensory channels, for example, audio and visual representations (pictures, charts and models). Multimedia teaching with visual materials were also found to provide more concrete meaning to words, show connections and relationships among ideas explicitly, and provide a useful channel of communication and strong verbal message and memorable images in students' (Cyrs, 1997, Çimer, 2004, 2007). Most of the challenges and difficulties in genetics that have been presented have affected pupils and teachers' attitudes towards genetics and, consequently pupils' performance in genetics.

1.2.2. Information and Communication Technology (ICT) in teaching and learning

ICT in education refers to the use of computer-based communication that is incorporated into the daily classroom instructional process. In conjunction with preparing students for the current digital era, teachers are seen as key players in using ICT in their daily classroom activities. This is due to the capability of ICT in providing dynamic and proactive teaching-learning environments (Arnseth and Hatlevik, 2012). Well, the aim of ICT integration is to improve and increase the quality, accessibility and cost-efficiency of the delivery of instruction to students. It also refers to benefitting from networking with the learning communities to face the challenges of current globalization (Albirini, 2006).

With the support of the International Institute for Communication and Development (IICD), the Commonwealth of Learning (COL), and the United States Agency for International Development (USAID), the Zambian Ministry of Education had developed a draft ICT policy for education by October 2006 and an implementation strategy by January 2007 (Shafika, 2007). This represents an extension of Zambia's national education and national ICT policies. The vision is for ICTs to contribute towards reaching innovative and lifelong education and training in Zambia by 2030.

The guiding principles of the policy include the following:

- It must fit into national policies on education and ICTs;
- There is a commitment to establishing strategic partnership with stakeholders;
- There is a combined effort with government, the private sector, and NGOs;
- The policy reflects general standards that the Ministry of Education wishes to uphold;
- An integrated approach must be adopted that integrates all aspects of the value chain in the education process.

The policy also provides an overview of goals, objectives, and government commitment in key programme areas of ICT infrastructure to education institutions, content development, curriculum integration, teacher training, distance education, administration and support services, and finance.

Zambia's Sixth National Development Plan [SNDP] (2011) also echoes education objectives that are directed at increasing access to ICTs and quality education. The objective number one and two state the need to increase access, efficiency and equity to equality Early Childhood Care, Development and Education (ECCDE) and Secondary Education. The way to achieve this is through many strategies such as strengthening Continuous Professional Developments' (CPDs'), introducing ICTs as a teaching and learning tool, and expanding alternative modes of education including ICTs (SNDP, 2011). Even with the notion of expanding alternative modes of education, including ICTs, the Ministry of General Education (MoGE) has not yet integrated ICTs in the teaching and learning of Biology nor any sciences that are really perceived as abstract subjects by most learners. Thus, the study investigated how ICT tools (Excel, videos and Gene X. 2.0 simulation software) could enhance pupil performance in genetics when it was used as an enhancement to traditional teaching-learning methods, the impact of ICT on pupils' performance in genetics, and explored the attitude of pupils and teachers on the use of ICT in the teaching and learning of genetics.

1.3. Statement of the problem

In Zambia, ICTs are used in every sector of our societies such as educational sector, financial sector and health sector. However, the penetration levels of ICT in Zambia's education remains low, with those schools that are equipped mostly utilising second-hand and refurbished computer contrary to the provisions of the 2006 ICT policy. Furthermore, the national ICT policy, as well as the development of the draft policy for education and associated implementation framework, provides an enabling policy environment to promote far greater access and use of ICTs across all sectors of Zambia's education systems, including a system for enhancing education management, administration and teaching and learning (Shafika, 2007). Additionally, the ICT education Policy (2006) and CDC (2013) objective emphasises on the use of innovative teaching approaches. While the goals, objective, targets and guiding principles on ICTs in education seems realistic and achievable, few educationists have taken a keen interest in how ICT integration in the teaching and learning of genetics would affect pupils' academic performance, and teachers'/ pupils' attitudes. Thus, the researchers' intent to investigate on the integration of ICT in the teaching and learning of genetics.

1.4. Purpose of the study

The purpose of the study was to find out the effect of integrating ICT during genetics lessons on the performance, and attitudes of pupils and teachers at two selected secondary schools in Kitwe district.

1.5. Research Objectives

The objectives of the study were:

i. To find out if ICT tools (Excel, videos, simulations) enhance pupil performance in Genetics in Biology at two elected schools in Kitwe district when it is used as an enhancement to traditional teaching learning methods.

ii. To determine the impact of ICTs on pupils' (gender and age-group) performance in genetics

iii. To explore the attitude of pupils on the use of ICT in the teaching and learning of genetics.

iv. To explore the attitude of teachers on the use of ICT in the teaching and learning of genetics.

1.6. Research questions

The study was guided by the following research questions:

i. How do ICT tools (Excel, videos, Gene X. 2.0 simulation software) enhance pupil performance in Genetics in Biology at two elected schools in Kitwe district when it is used as an enhancement to traditional teaching learning methods.

ii. What is the impact of ICTs on pupils' (gender and age-group) performance in genetics?

iii. What are the attitudes of pupils on the use of ICT in the teaching and learning of genetics?

iv. What are the attitudes of teachers on the use of ICT in the teaching and learning of genetics?

1.7. Research Hypothesis

1. H_{o1}: there is no significant difference in pupils' performance when ICTs are used as enhancement tools to traditional teaching and learning of genetics.
2. $H_{o2:}$ there is no significant difference in pupils' attitudes when ICT is used in the teaching and learning of genetics.
3. H_{o3}: there is no significant difference in teachers' attitudes when ICT is used in the teaching and learning of genetics.

1.8. Significance of the study

The researcher has been a teacher of biology in Zambia and currently lecturing Genetics at Mukuba University. For a long time, the performance in genetics at general certificate examinations has been consistently poor (E.C.Z, 2013; E.C.Z, 2014; E.C.Z, 2014; E.C.Z, 2015; E.C.Z, 2016). The study might stimulate further research by the academicians especially in the field of science education on the use of the latest software packages in primary and secondary school science related subjects, such as biology (Genetics). This in turn could help the educationists to appreciate the use of ICT tools or computer based learning more and utilise it effectively to supplement traditional teaching approaches. Therefore, improving the teaching and learning of science education and other related subjects in education. Additionally, since the use of ICT tools is still evolving in Zambia, the study might not only bridge the knowledge gap in computer based instruction in our society but also supplement the existing literature on the scaffolding learning approach. Finally, the knowledge from the study might be used to increase the attitude of teachers and pupils in the use of ICT in the teaching and learning of genetics.

1.9. Scope of the study

The study was conducted in two secondary schools in Kitwe District. The schools were purposively selected because there was a need of using a full school computer laboratories and other ICT tools such as the projector and smart screens.

1.9.1. Limitations of the study

This study was conducted in two selected secondary schools in Kitwe District because of the availability of ICT tools and laboratories in these schools. Further, with the limited time in third term when the topic is usually taught, the researcher randomly sampled two classes from each school to form four groups. The researcher could not have selected more than two schools because time was limited. Therefore, the findings will not be generalised beyond the study sites. Thus, to generalise the results to a larger group, the study should have involved more respondents and different schools that are geographically isolated.

1.9.2. Delimitations of the study

The study targeted teachers of biology in regular secondary schools in Kitwe District. Further, it also targeted learners that take biology, especially, grade 12 in selected secondary schools of Kitwe District, Copperbelt Province. Finally, the researcher targeted schools that were well equipped with the ICTs and computer laboratories and were geographically further apart from each other.

1.10. Theoretical framework

The study was being guided by the instructional (educational) scaffolding theory coined by Wood, Bruner and Ross (1976) in their report, "The role of Tutoring in Problem solving." Instructional scaffolding theory is a learning process designed to promote a deeper level of learning. Scaffolding has been defined by Wood, Bruner and Ross (1976:23) as an "adult controlling those elements of the task that are essential beyond the learners' capacity, thus permitting him concentrating upon and complete only those elements that are within his range of competence." The works of scaffolding has been linked to the works of the Soviet psychologist Lev Vygotsky. However, Vygotsky never used the term scaffolding, but believed that learning first occurs at the social or inter-individual level and emphasised the role of social interactions as being crucial to cognitive development (Vygotsky, 1978). Scaffolding is the support given during the learning process which is tailored to the needs of the student with the intention of helping the student achieve his/ her learning goals (Sawyer, 2006). Instructional scaffolding is the provision of support to promote learning when concepts and skills are being introduced to students. These supports may include the following:

- resources;
- compelling tasks;
- templates and guides;
- guidance on the development of cognitive and social skills.

Instructional scaffolding can be used in the variety of ways in the teaching and learning, namely: -

- modelling a task;
- giving advice;
- promoting coaching.

These supports are gradually removed as students develop autonomous learning strategies, thus promoting their own cognitive, affective and psychomotor learning skill and knowledge.

1.10.1. Essential features of instructional scaffolding

There are three essential features of scaffolding that facilitate learning (Beed *et al*, 1991; Wood and Wood, 1996). The first feature has to do with the interaction between the learner and the expert (teacher). This interaction should be collaborative for it to be effective. The second feature is that learning should take place in the learner's zone of proximal development (ZPD). The ZPD is the difference between what the learner can do without help and what the learner can do to help. To do that the expert (Teacher) needs to be aware of the learner's current level of knowledge and then work to a certain extent beyond that level. The third feature of scaffolding is that the scaffold, the support and guidance provided by the expert, is gradually removed as the learner becomes more proficient (Palincsar, 1986). The support and guidance provided to learners facilitate internalisation of the knowledge needed to complete the task. This support is weaned gradually as the learner is independent (Bruner *et al*, 1978).

1.10.2. Effectiveness of scaffolding

For scaffolding to be effective, the teacher (researcher) need to be attentive to the following:

i. The selection of the learning task: the task should ensure that the learners use the developing skills that need to be mastered, and the task should be engaging and interesting to keep learners involved (Bruner *et al*, 1978; Hogan and Pressley, 1997).

ii. The anticipation of errors: after choosing the task, the teacher needs to anticipate errors the learners are likely to commit when working on the task. Anticipation of errors enables the scaffolder to properly guide the learners' way from the ineffective directions.

iii. The application of scaffolding during the learning task: scaffold could be organised in "simple skill acquisition or they may be dynamic or generative (Rosenshine and Meister, 1992).

iv. The consideration of emotive of affective factors: Scaffolding is not limited to a cognitive skill, but it is also related to the emotive and affective factors. During the task the scaffolder (teacher) might need to manage and control for frustration and loss of interest that could be experienced by the learner (Bruner *et al*, 1978). Thus, encouragement is also an important scaffolding strategy (Schetz and Stremmel, 1991).

Thus, the theory was very useful in data collection and analysis for the researcher as it tackled aspects of Collaboration, cognitive improvement and positive attitudes among learners.

1.11. Organisation of the Study

The dissertation is organised into six chapters.

The First Chapter outlines the topic, background of the dissertation and statement of the problem. It highlights the purpose of the study, specific research objectives, and research questions, significance of the study and delimitation of the study. Operational definitions as well as theoretical framework on which the study is based on.

The Second Chapter reviewed literature according to the objectives and some items on the research instruments.

The Third Chapter outlines the methodology adopted in the study. It discusses the research design, population, methods and techniques applied in data collection and analysis; the ethical considerations.

The Fourth Chapter specifically deals with an account of the findings of the study. The findings are presented using research questions and whether the data was quantitative or qualitative.

The Fifth Chapter presents the discussion of the findings. To discuss the findings, the research objectives, literature review and theoretical framework are used.

Chapter six concludes the study and recommendations of the study are drawn. Finally, the study proves the fields for further research.

CHAPTER TWO: LITERATURE REVIEW

2.1. Overview

This chapter reviews the literature that is related to ICT in education in Zambia and globally. The literature was reviewed according to the objectives and some items on the research instruments.

2.2. Zambian national ICT policy in education

Habeenzu (2010) stated that in 2001, the Government of Zambia, with assistance from the Japanese International Cooperation Agency (JICA) through the United Nations Development Programme (UNDP), embarked on the formulation of a National Information and Communication Technology (ICT) policy. The policy formulation process was completed in 2005. This prolonged process also served to raise general public awareness of the role of ICTs in fostering socio-economic development. The policy is oriented around thirteen pillars, of which the third relates to the education sector and states, 'education- To integrate ICTs in the education system and nation's research and development,' (Habeenzu, 2010).

It is evident that the Zambia National ICT policy also recognises the potential of ICT in education. With the support of the International Institute for Communication and Development (IICD), the Commonwealth of Learning (COL), and the United States Agency for International Development (USAID), the Former Minister of Education (MOE) together with the Minister of Communication and Transport developed a National Information and Communication policy (NICP, 2006) with the vision, "to enable all schools in Zambia have access to ICTs by 2030. This was in order to provide and promote lifelong education and training to all. The ICT policy was formulated in line with the Fifth National Development Plan.

In education, various ICT technologies are shaping the way the education delivery is being conducted. For instance, Interactive Radio Instruction (IRI) provides access to education for children who do not have schools and teacher. Through IRI, basic education is being delivered to out-of-school children, in particular orphans and vulnerable children (Bosch, Rhodes and Kariuki, 2002). The programme is the result of collaboration between communities, churches, non-governmental organisations (NGO's), the Ministry of Education's Educational Broadcasting Services (EBS), and United States of America Peace Corps. The radio programmes were developed and broadcast by EBS, which also developed supplementary materials such as mentor's guides. In 2000 and 2001, EBS produced and broadcasted 30 minutes' lessons for grade one on a daily basis. These lessons followed the Zambian curriculum for Mathematics and

English, and the learners were guided in through the process by a facilitator. Lessons for grade two and three have also been developed. Early evaluations suggested that the programme had positive effects on learning (Bosch, Rhodes and Kariuki, 2002). The study further stressed that ICTs have positive effects on learning (Bosch, Rhodes and Kariuki, 2002).

2.3. Effects of integrating ICT on academic performance

According to Macho (2005) the use of ICT in education would enhance students' learning. This notion could have a significant effect on pupils' performance in various fields of education. The study conducted by Kaulu (2008) revealed that the use of computer based instructions enhances performance when used as a supplement in the teaching and learning process. The study revealed that physics classroom computer software enhanced the performance of pupils in kinematics in school physics more than when traditional approaches when used in the teaching and learning process. The study further revealed that the experimental group performed higher than the control group with the percentage difference of 10.5%. Ghavifekr and Rosdy (2015) also asserted that ICT integrated into the teaching and learning processes increases learners' performance and improved cognition in academics.

Orora, Keraro and Wachanga (2014) conducted a study on the effects of cooperative e-learning (CEL) teaching strategy on students' achievement in secondary school Biology. The study revealed that students who were exposed to CEL strategy achieved significantly higher scores in the Biology Achievement Test (BAT) compared to those taught using conventional methods. The study further implied that the CEL teaching strategy was more effective in enhancing student's achievement than the conventional methods. Wachanga (2002) further compared the effects of traditional and co-operative class experiment learning strategies on students' achievement and motivation in secondary school chemistry. The study revealed a significant difference in students' achievement. Students who were taught using cooperative class experiment methods were found to have higher achievement in Chemistry than those taught using traditional methods. However, the rewards or scores in the study were based on the individual learning of the group members. This made students to make sure that every member of the group mastered the content in order to boost their group grade.

Arman (2013) carried out a study on the effectiveness of ICT approach on students' 8th grade achievement in mathematics in Palestinian schools. He examined an experimental group of 48 students after studying a course that integrated the use of ICT in instruction. The students' achievement was examined before and after the experiment. The results indicated that there was an increase in the mean scores by a gain value of 8.94 after the ICT intervention. The study revealed that there was a significant difference in achievement at $p = 0.05$ level between the mean scores of the pre-test and post-test.

According to Ghavifekr, and Rosdy (2015) integration of ICT in education, and the knowledge of ICTs makes both teachers and learners better able to participate fully in the teaching and learning process. Their study also revealed that academic performance and improved cognition in academics by learners have shown to increase when ICT is integrated into the teaching and learning processes. Thompson (2007) also argues that ICT has the potential to provide unlimited access to information and content that is undesirable to learners, thus projecting a strong negative belief relating towards its use. However, Thompson asserts that the next generation of students often referred to as the 'Net Generation', are expecting the integration of Web 2.0 technologies into their learning and teaching programmes. It is therefore important that both teachers and learners have a bridging point where they can be able to appreciate ICTs and be able to implement it in the teaching and learning process.

According to Shaheen and Khatoon (2017) ICT enriched modular proved very useful in enhancing achievement scores of experimental groups. When ICT enriched modular approach groups' mean scores were compared to the post test, it was found that the mean of the experimental groups (45.24) was much greater than control group (40.12) The p-value was significant at alpha 0.05 showing the preeminence of ICT enriched modular approach over traditional lecture method.

Hermans, Tondeur, Van-Braak, and Valcke (2008) have identified three main stages for ICT to be highly valued and regarded by the teachers; integration, enhancement and complementary. Integration approach is about implementing the right use of ICT in particular subject areas that involved complex concepts and skills to improve students' achievement and attainment. Besides, the review of the curriculum is also needed so that only related ICT resources and appropriate software will be installed for the main aims and objectives of curriculum to be achieved. Enhancement approach is about using ICT to give great emphasis on the topic introduced. For instance, Microsoft PowerPoint can be used to present the topic in a very innovative and creative way that will lead into discussion and exchanging ideas and thoughts. Finally, complementary approach is when the ICT is used to aid and support the student's learning. This approach allows students to be more organized and efficient in which they can take notes from the computer, submit their works by email from home as long as they meet the deadline, and look for information from various sources provided online to fulfil the task given to them (Hermans *et al*., 2008).

Opara (2011) found that the mean score of the students taught using inquiry was 54.3 with a standard deviation of 10.54 while the control group that was taught using conventional methods had a mean achievement score of 24.3 with a standard deviation of 4.95. The Z calculated for these means was greater than the Z critical, therefore, the null hypothesis was rejected meaning that inquiry teaching method was considered to be superior to conventional methods. The study further revealed that the experimental group students who were taught using the inquiry method performed better than students in the control groups who were taught using conventional methods (lecture).

Gordijin and Nojhof (2002:183) who investigated the 'Effects of Complex Feedback on Computer Assisted Modular Instruction' deduced that "the application of complex feedback is somehow effective but does not increase the post test result notably".

2.4. Impact of ICTs on the performance of pupils with regard to gender and age group

2.4.1. Impact of ICT on gender and group names

There are many factors that impact on academic performance of pupil as they are engaged in the teaching and learning process. Some factor includes gender, age group, attitudes, pedagogical approaches, self-concept, socio-economic and cultural factors all have the impact on pupils' academic performance in genetics. However, according to FAWE (1993), low self -esteem, poor self-image, non-assertive behaviour among girls, and poorly trained teachers contribute to girls shying away from science and mathematics.

FAWE (1993) further asserts that girls believe boys are more superior and intelligent and more capable of handling difficult subjects. Boys in turn perpetuate this myth by dominating in most of what they consider to be "masculine zones" such as computer rooms, science laboratories and technical equipment or engineering laboratories. UNESCO (2004) also argues that teachers often consider girls as less intelligent and destined for less well-paid jobs than boys. Girls are also given little praise compared to boys.

In a study by FAWE (1998) that aimed at improving the participation and performance of girls in science and mathematics in primary and secondary schools in Kenya, it was reported that girls' achievement was much lower than that of boys partly due to their poor attitude towards science. It also indicated that teachers in normal competitive classes use discouraging remarks on girls' participation in learning science (FAWE, 1998).

In a study by Eriba and Sesugh (2006) on gender differences in achievement in Markurdi metropolis, Nigeria, it was found that boys outperformed girls in science and mathematics achievement. Another study that was conducted by Ewumi (2011) carried out a study on gender and socio-economic status as correlates of students' academic achievement in senior secondary schools in Ogun state, Nigeria. He found a significant relationship between gender and students' academic achievement ($r = -0.21$; $p < 0.05$). The significant relationship indicated that the male participants achieved higher than the females. However, Klein (2004) attributed the differences in scholastic achievements of male and female due to biological causes and cultural stereotypes.

According to Shaheen and Khatoon (2017) gender differences revealed that female students performed significantly better on the posttest than male students. However, Khatoon (2004), revealed that boys performed better than girls in general comprehension while there was no significant difference between male and female students in textual comprehension.

However, other research studies have reported that males are becoming disadvantaged in schools, and fewer males are interested in science (Weaver-Hightower, 2003; Omoniyi, 2006). This meant that the academic performance towards the sciences in males may be affected negatively and the females will start performing better in the sciences.

The study by Olukemi (1998) on the participation of girls in science and technology education in Nigeria showed that the cognitive power necessary for science endeavours is not foreign to girls. He further asserted that the science ability correlates highly with general intelligence in which no consistent gender differences were found. This implies that no gender has advantages over the other in science achievement.

Another study by Afuwape (2011) investigated the relationship between students' gender and academic performance in Basic science in Nigeria. Three hundred (300) students from public schools participated. Findings indicated that no significant gender difference in achievement was found. Nevertheless, female students were found to be slightly better with a mean score of 16.13 in basic science than their male counterparts whose mean score was 16.07. He further asserts that there are no longer distinguishing differences in cognitive, affective and psychomotor skills achievement of students with respect to gender.

Thus, the use of alternative modes of teaching and learning (using ICTs) can be bring about positive changes in the academic performance of both girls and boys in sciences. Furthermore, the use of instructional scaffolding theory in the teaching and learning processes can also break the barriers such as low self-esteem, socio-economical and gender orientation among learners in the teaching and learning of genetics using ICT tools. This might improve academic performance of both girls and boys in genetics when ICTs are used in the teaching and learning processes.

2.4.2. Impact of ICT on pupils' age group

Shaheen and Khatoon (2017) age groups of the students had no significant role in the achievement of biology students. The same study also found that there was no interaction of age groups with groups (experimental & control) or sub groups (high achievers, moderate and low achievers). But the findings revealed that students in the experimental group performed better than students in the control group in spite of their age group.

Bulić, Jelaska and Jelaska (2017) findings that clearly indicated that the age-factor is a significant predictor of success, regardless of pupils belonging in the experimental or control group. The researchers further argued that the age of the pupils was in favour of the application of e-learning in the second educational cycle as the factor of Age was identified as the predictor of efficient e-learning, in teaching.

Didia and Hasnat (1998) examined the determinants of student performance in an introductory finance course. They found that age, as a measure of maturity, had a significant influence on performance. Reid (1983) focused his study on an introductory university economics course and also found that age was a significant variable with older students performing better than younger ones.

These studies will help the researcher to discuss and provide the inferences on whether the pupils performance in genetics when ICTs are used in the teaching and learning processes have any bearing on their age groups. Further, the study also took place in a natural environment we almost all pupils despite their differences in their age groups had the same opportunities to learning and interact with the researcher evenly.

2.5. Teachers and pupils' attitude towards ICT use

Sánchez *et al* (2012) concluded that teachers showed a positive attitude towards the use of computer tools with the score of 3.83 (from 1= strongly disagree to 5=strongly agree). Their study further revealed that teachers were ready to continue using computer tools in the classrooms. Furthermore, Sánchez *et al* (2012) reached an understand that most of the teachers were ready to continue learning computer tools for their use in the classroom. Sánchez *et al* (2012) concluded that teachers considered that computer tools were helpful to keep pupils' attention, improve the intervention with pupils with difficulties, improve the motivation and academic performance of both teachers and pupils.

Mehra and Newa (2009), Husain (2010) and Ndibalema (2014) whose study revealed that teachers exhibited a positive attitude towards the use of ICT. The studies further asserted that ICT must be given higher priority in teacher education curriculum, so that the future teachers can cope with various challenges in education system and more specifically the new roles of teachers in ICT based teaching-learning system.

However, Hew and Brush (2007) in their study found that teachers had negative attitudes ICT. Another study conducted by Sarangi (2003) also found that teacher educators have a low positive attitude to ICT though not negative.

According to Ang'ondi (2013) the government of Kenya rolled out the Economic Stimulus Programme (ESP) -ICT project in which it aimed at equipping 1050 schools with ICT infrastructure and capacity building of teachers in the area of ICT integration. It was expected that the current and future inventions will inject the much needed ICT infrastructure, skills and attitudes necessary to spur ICT integration in teaching and learning in schools. A study by Ang'ondi (2013), further revealed that the teachers were also enthusiastic about ICT integration, however, there were several challenges that were still holding them back from fully utilising the ICTs. Issues such as inadequate infrastructure, lack of knowledge and skills on how to integrate ICTs, their own attitudes and beliefs and curriculum, were challenges that the teachers seemed to point out as impediments to the smooth integration of ICTs.

A study by Yang and Kwok (2017) showed that pupils are eager to embrace the use of ICTs in the teaching and learning of genetics, despite them belonging to either control or experimental groups. Furthermore, all 737 participants who answered the questions on the questionnaire showed a positive attitude to the constructs that were measured in this study. According to the study, all means were above the midpoint of 3.0, ranging from 3.47 to 3.80. The small standard deviation values ranged from 0.81 to 0.90, indicating a narrow spread of item scores around the mean.

Other research studies have demonstrated that females had more positive attitudes towards ICTs than males (Volman, van Eck, Heemskerk & Kuiper, 2005; Bove´e, Voogt and Meelissen, 2007).

Zhang (2013) study on the Internet Use in English as Foreign Language (EFL) Teaching and Learning in Northwest China indicated that teachers and pupils showed a positive attitude regarding the use of the Internet in teaching and learning of English. Additionally, Zhang (2013) concluded that new generations students who grow up as a net generation should also facilitate the process of English Learning on the internet. Tezci (2011) that shows most of pre-service teachers indicated that they only associate elementary ICT tools for educational use. Teachers thought that ICT integration was effective, but ICT tools that were provided in the school were not enough nor in good condition.

Furthermore, a research by Chien, Wu and Hsu (2014) has shown that students in school are having high expectation on ICT integration in classroom. This is because the new generation of students are born and grown with technologies, and thus, they could be defined as the "digital native phenomenon" to ICTs. Additionally, their study revealed that the younger the students, the higher their expectations are on ICT integration in classroom. Chien, Wu and Hsu (2014) study also proved that the integration of ICT is mostly dependent on the personal factors such as self-perceptions. Accordingly, Chien, Wu and Hsu (2014) research also showed that teacher and students accepted the used of ICTs and related technologies within and outside classroom. Finally, Chien, Wu and Hsu (2014) concluded that the barriers of ICT integration in classroom were confidence, competence and attitudes of teachers that reduced the percentage of ICT integration.

Studies have established positive attitude among educators in Nigeria towards computer education. For example, Yoloye (1990) found that educationist at the University of Ibadan had positive attitudes towards computer and, in fact, would like to be trained in the use of computers. Similarly, most teachers in Nigeria have positive attitudes towards computer education (Yusuf, 1998).

In a "Meta-Review of the effects of Innovative Science and Mathematics", Savelsbergh *et al*. (2016) described studies of ICT-rich teaching approaches as; inclusive of (individualised) computer-based instruction, games, feedback, interactive quizzes, computer based labs, simulations and robotics. Furthermore, Savelsbergh *et al*. (2016) asserted that ICT-rich teaching approaches lead to gain in more positive attitudes where 'students enjoy working with computers, students feel more safe to experiment and make mistakes, and/or students appreciate the (quick) feedback that ICTs as able to provide. Finally, Savelsbergh *et al*. (2016) found that innovative strategies (computer-based, inquiry-based, context-based, collaborative learning, extra-curricular activities) produced effects on student attitudes and achievement in science and mathematics. However, their study also showed that there was no significant difference between the teaching approaches that were used.

2.6. Factors affecting the use of ICT in teaching and learning processes.

Mwanda, Mwanda, Midigo and Maundu (2017) study revealed that most schools in Kenya had few computers; teachers had inadequate training on use of computer applications; most teachers did not use computer technology for personal growth and instructional purposes. Further, the study revealed that most of the sampled schools had inadequate number of computers which was a major challenge facing the integration of computer into the instruction process.

Bingimlas (2009) found that teachers had a strong desire for the integration of ICT into education but they encountered many barriers. Among the major barriers that teachers encountered were; lack of confidence, lack of competence and lack of resources. Bingimlas (2009) asserted that lack of confidence, competence and accessibility to ICTs have been found to be critical components of technology integration in school. Furthermore, ICT resources such as hardware and software, effective professional development, sufficient time and technical support need to be provided to teachers and schools to elevate some of the barriers to ICT integration. A study by Bingimlas (2009) also established one component of ICT in itself is sufficient to provide good teaching, but the collaboration of different ICTs. However, the presence of all components in ICT increases the possibility of excellent integration of ICT in teaching and learning opportunities.

According to Education and Manpower Bureau (2008), the Malaysian authority recognised the deeper needs of educational performance, incompetence of teachers and the inadequateness of hardware and software. It indicated that the ICT culture in schools should be improved with the use of ICT among teachers through training of teachers in ICTs. (Hussain, Morgan, and Al-Jumeily, 2011). Education and Manpower Bureau (2008) spelt out that the main goal of ICT implementation in education proclaimed the vision and missions of the government to promote ICT in education for the following intentions:

1. To surround schools with dynamic and innovative learning environments for students to become more motivated and creative;
2. To enable students to gain a wider range of knowledge and be able to access internet for developing a global outlook;

3. To nurture students with capabilities of processing information more effectively and efficiently; and
4. To develop students with attitudes and capability of lifelong learning.

Tezci, (2011) asserted that training and professional development in ICT were not adequately provided for teachers in Turkey. He further argued that technical supports were somehow provided, but could be improved from time to time. Computer laboratories and well-function ICT tools and facilities were not in good condition in most schools.

Another key factor that affect the use of ICT in the teaching and learning process is the availability of sufficient computer laboratories and ICT equipment in schools. This is to ensure that subject teachers easily have access to ICT tools whenever needed (Hennessy, Ruthven, and Brindley, 2005). Thus, lack of adequate ICT equipment and internet access is one of the key problems that most schools, specifically in rural areas are facing now. For example, results from a research in Kenya shows that, some schools have a computer, but this could be limited to one computer in the office only. Even in schools with computers, the student-computer ratio is high. According to Chapelle (2011) those schools that are equipped with ICT infrastructure are supported by parents' initiative or community empowerment.

Wagner (2001) states that ICTs are being considered a major tool for improving accessibility to and efficiency of education in developing countries. ICTs are also being viewed as a 'flat world' enabler by providing access to the latest educational content development all over the world. However, despite many promising efforts, there is still a significant digital division between educational institutions located in developing and developed countries. This includes policy and poor ICT infrastruction, lack of training facilities and training, maintenance personnel, limited community participation, gender related issues and ICT access issues especially in rural areas of most African countries.

In most schools, technical difficulties sought to become a major problem and a source of frustration for students and teachers and cause interruptions in teaching and learning process. If there is lack of technical assistance and no repair of ICT, teachers are not able to use the computer for temporarily (Jamieson-Proctor *et al*., 2013). The effect is that teachers will be discouraged from using computers because of fear of equipment failure since they are not given any assistance on the issue.

Türel and Johnson's study (2012) revealed that technical problems become a major barrier for teachers. These problems include low connectivity, virus attack and printer not functioning.

However, there are a few exceptions. Schools in the countries like Netherland, the United Kingdom and Malta have recognized the importance of technical support to assist teachers to use ICT in the classroom (Yang and Wang, 2012).

ICT provision and facilities in schools were found to be poorly equipped to deliver ICT, not least because some still operated in “rented houses” (i.e. in buildings that were not purpose-built to serve as schools), shortages of computer equipment (Abatain, 2001; Alshowaye, 2002).

Sahin-Kizil (2011) also reviewed that the use of ICT for educational purposes yield positive outcomes on the part of the students such as increased motivation, active learning, providing efficient resources and better access to information. Moreover, Wang and Woo (2007) reviewed that technology has great potential to increase learners' motivation, link learners to various information sources, support collaborative learning, and allow teachers more time for facilitation in classrooms.

2.7. Significance of ICT in education

The UNESCO policy on ICT states that ICT can help strengthen democratic and transparent education planning and management. Communications technology can expand access to learning, improve equality and ensure inclusion. Where resources are scarce, judicious use of open-source material through technologies can the means to bypass the bottleneck of textbook production, distribution and updating (UNESCO, 1995).

ICT provides pupils with a learner-centred environment, opportunities to make decisions and to develop critical thinking skills, opportunities to build new knowledge, analyse, synthesize and assess data and learning materials, (Castro, Sánchez and Chirino-Alemán, 2011; Fu, 2013; Lu, Hou, and Huang, 2010; Chai, Koh, and Tsai, 2010). Additionally, ICT allows students to learn through discovery and inquiry, and to solve problems. Autonomy, capability, and creativity are the three characteristics that enhance learning (Fu, 2013; Lowther *et al*., 2008).

William (2004) argues that research clearly demonstrates the potential of ICTs to increase motivation and autonomy in learning and teaching, and further improve retention of knowledge and skills. The use of multimedia to mediate directly to students, at their own pace, realities and experiences which would otherwise be text-based stimulates their interest and motivation. William (2008) further avows that ICT has been observed that when students collaborate in pairs on computers or other ICTs, they experience greater autonomy and self-direction, and teachers become less directive. In doing so, learners tend to experience independent learning which, in turn, fosters confidence in the learning process among themselves.

Saverinus and Williams (2008) studies show the emerging important role of ICTs in education. Their studies show that when ICTs are used in education, it has increasing positive effects such as increased motivation among learners and teachers, autonomy in learning and improved retention levels among learners. Additionally, increased motivation can raise positive attitude in learner and teachers.

A study by Maimum *et al* (2011) on the integration of ICTs in the teaching of Islamic Religious subjects, stressed that ICTs may be used as a medium for teaching and learning to develop a more creative thinking in the integrated education process. Then, it is of paramount importance to teachers and educationists that the new era of ICT in education should be developed rapidly to appropriate extent in order to match the capability of students as well as teachers in educational experience due to the development of new information technology which is able to develop a more creative thinking in the integrated education process.

Mewcha and Ayele (2015) proposed that Adwa college in Ethiopia should critically focus to integrate ICT in each course to make courses interactive and easily understandable by their students. They further assert that teachers' productiveness is realised if ICT usage is integrated into the courses they teach. Their study provided that the Adwa college should provide ICT resources such as hardware and software, effective professionals' development and technical support to teachers and create environments for students in ICT usage.

ICTs was perceived to help Religious Education (R.E) teachers teach better and learners learnt better, promoted: participation, ambiance transformation in class, creativity, motivation, easier understanding, and higher retention levels among learners in religion studies (Mulima, 2013).

Furthermore, Zhang (2013) argued that ICT helps students develop the confidence, be more creative and imaginative as their knowledge paradigm expand. Zhang (2013) further argued that ICTs can better students' communication, knowledge and helps students to possess all four skills in learning through the acquisition of necessary information. ICTs can also help students to be able to express their thoughts and ideas coherently through the resources that ICTs are able to provide during the teaching and learning process. Gee (2007, 2011) also established that ICT fosters pupils' creativity and improves both teaching and learning quality.

2.8. ICT as a teaching and learning resource

The UNESCO policy on ICT states that ICT can help strengthen democratic and transparent education planning and management. Communications technology can expand access to learning, improve equality and ensure inclusion. Where resources are scarce, judicious use of open-source material through technologies can the means to bypass the bottleneck of textbook production.

Loveless (2011) however, relates to more recent research into the role of technologies for enhancing 'good pedagogical design' to express congruence between content and implementation (teaching strategies, learning environment, assessment and feedback, underlying learning theories). The author defends educators' use of technology as grounded in 'Why?', 'What?' and 'How' questions around their vision and beliefs about 'why they think their practice matters and how they can best design experiences and environments for pupils.'

Moreover, the mobile devices come preinstalled with social media applications like Facebook, Twitter, Wikipedia, YouTube, WhatsApp, Telegram, Instagram, Snapchat 'which are part of what is known as Social Web 2.0, best characterised by the notions of social interaction, content sharing, and collective intelligence' (Alabdulkareem, 2015: 214). This platform can be used be teachers to disseminate information such as homeworks, assignments and provide instant live feed-feedback to learners' misconceptions and questions pertaining to the topic under discussion. However, the teachers should at all cost regulate the usage of the social media platform by coming up with ground rules that strict its usage to avoid the platform being misused in a non-academic way.

However, educators' perspectives have been raised on adapting these kinds of tools and creative media skills for engaging students 'to become the authorities on subjects through investigation, storytelling, and production' (NMC-CoSN, 2016.18). For example, students and teachers in New Zealand and Singapore are using WhatsApp as a platform to build intercultural understanding and to foster longer term teacher collaboration towards meeting student 21st century learning needs (Asia New Zealand Foundation, 2016).

Similarly, social media platforms like Twitter are being used by teachers and students in a multiplicity of ways, for example: to discover new information; to generate discussion, interest and collaboration; to connect with local and global issues; to explore, exchange and publish thoughts, ideas and perspectives; to communicate information and join professional learning networks (Shannon *et al*., 2011; e-Learning Industry, 2016).

The growing accessibility of mobile technologies (in the form of smart phones, iPads, iTunes and smart watches), handheld digital assistants and ubiquitous laptop computer distribution point to increasing affordances for pupils 'to work more continuously across home and school settings, [in] activities to be initiated outside the school, or practice on exercises to be undertaken when or where desired' (Passey, 2010). A study by Mulima (2013) that ICTs were valuable pedagogical tools in enhancing the teaching and learning of Religious Education.

Other research studies have revealed that teachers use of computers, visual materials like charts, posters and models (computer simulated), were found to be effective for making the lessons attractive and interesting for students (Mistler-Jackson and Songer, 2000; Paul and Fernandez, 2000).

According to Aguilar (2012), the transformation of ICT has allowed ICT tools to become educational tools that could further improve the educational quality of the student and revolutionise the way information is obtained, managed and interpreted. Cyrs (1997) and Çimer (2004, 2007) concretised this concept by asserting that providing information in such different modalities (audio, visual, pictures, models and charts) provide more concrete meaning to words, show connections and relationships among ideas explicitly. Cyrs (1997) and Çimer (2004, 2007) further asserted that teaching using different modalities provide a useful channels of communication, strong verbal messages and memorable images in students.' This has a way of increasing students' motivation, attitude and improve students' achievement.

According to Xenofontos *et al*. (2016) two conditions were compared, the experimental condition (use of the Experiment Design Tool **[**EDT]) and the control condition (no use of the EDT). In each condition, an Inquiry Learning Space [ILS] (an online learning environment) and a virtual lab were selected from the Go-Lab learning platform known as EDT. The results revealed that the integration of the (EDT) in a computer supported inquiry learning environment facilitated the advancement of content knowledge, whereas the development of inquiry skills requires longer experience with such EDT tools or learning environments.

Dede (2014) describes that the use of EcoMUVE (multi-user virtual environment ecosystem) in middle grade curriculum initiative engages students to assume the role of scientists and enable them to investigate research questions by exploring the project virtual environment, and collecting and analysing data from a variety of sources over time. Findings from the project research showed that while students were initially preoccupied with the technology interface of itself, with time they became 'increasingly engaged in the student-led, collaborative inquiry experiences afforded by the embedded scientific investigation' (Metcalf *et al*., 2014).

According to Ayala (2012) ICTs, as technological tools have increased the degree of significance and educational conception, establishing new models of communication, besides generating spaces for training, information, debate, reflection, among others, as well as breaking up the barriers of traditionalism in the classroom. Granados (2015) further argued that the use of ICT means breaking with traditional media, boards and pens, and giving a way to a teaching role based on the need for training in and updating one's knowledge of teaching methods based on current requirements. This is because ICTs have been found to increase students' engagement, which leads to increased amount of time students spend working outside class time when it is used in the teaching and learning process (Becker, 2000).

Alkahtani (2017) also asserted that ICT is believed to enhance work and education in other ways. He further argued that ICTs can be used to deliver lessons with interesting and enjoyable real-world examples, and stimulating visual and audio illustrations from an extremely wide range of sources. His study further augmented that ICT offers well-known benefits such as efficient new ways to compose documents and organize and store information. These components of ICTs can be integrated in the education system to facilitate learning. He pointed out that emails can help teachers and students communicate outside class, holding online tutorials or submitting or returning homework, as well as allowing teachers and students to share their ideas with teachers and students in other schools. Additionally, dedicated software can be used for students with special needs (such as slow learners) and explaining abstract concepts (Alkahtani, 2017).

Fu (2013) also found that ICT facilitates learning without the boundaries of time and place. Fu (2013) further asserted that ICT provides abundant resources such as videos, visual presentation, and online materials. For example, online course materials and teleconferencing classrooms foster simultaneous interaction between the learner and the teacher and among the pupils themselves (Heemskerk, Volman, Admiraal, and ten Dam, 2012). Isling-Poromaa (2015) further avowed that ICT gives educational equality due to its motivating effects and its ability to differentiate teaching.

Hence, ICT is a powerful force required for educational reform so that it can be used effectively in classrooms for instruction, knowledge, and assessment (Player-Koro, 2012). Stošić (2015) study also revealed that educational technology improves the quality of education since it includes instructional materials and captures behaviour of all participants in the educational process.

Others research studies have also augmented that ICT can improve educational quality and associate learning to everyday situations (Lowther, Inan, Daniel Strahl, and Ross, 2008).

2.9. Teachers and pupils' ICT skills and knowledge

Teachers and pupils' ICT skills and knowledge play the significant role in determining the attitude and usage of ICTs by teachers and pupils in the teaching and learning process. ICT skills can influence the behaviour of teachers and pupils towards its usage in classroom activities. Furthermore, the knowledge teachers and pupils have on ICT can also influence the choice and usage of ICTs that can be used in the teaching and learning process. According to the study conducted by Husain (2010) teachers thought that using ICT skills in developing and presenting information was an essential technical competency that teachers need to acquire to improve the educational system. Nevertheless, the study by Zhang (2013) revealed that teachers have some knowledge about Internet use in teaching and learning, but could not very well integrate Internet into teaching and learning. The study further revealed that teachers' knowledge about ICT and network technology was found to be very limited.

A study by Abd Rahim and Shamsiah (2008) established that trainee teachers in Malaysia have confidence to integrate ICT in their teaching practices. And the male teachers are more confident than female teachers in using ICT integration in teaching. Moreover, other research studies have shown that vocational teachers are more confident to integrate ICT in teaching, because they can handle technical subjects, and their experiences enable them to integrate ICT effectively in teaching (Abd Rahim and Shamsiah, 2008; Yunus, 2007). Furthermore, only minority of teachers in Malaysia professionally know the basic of ICT.

Rosnaini and Mohd Arif, (2010) study also revealed that the majority of teachers just had average knowledge in ICT and even a group of the teachers are poor in the related knowledge of ICT in Malaysia. The study further revealed that the level of ICT knowledge among teachers is one of the key factors for Malaysia society to make successful adoption of ICT in its education.

In another study that was carried out by Mewcha and Ayele (2015) the findings revealed that teachers were unable to use of ICT software and hardware in the teaching and learning process. They reported that 55.6% of teachers could not use ICT as instructional tools. This indicate that most teachers in the college were not integrating ICT in the courses they were teaching. However, the majority teachers pointed out that one of the barriers to technology implementation was lack of teachers' technical knowledge and shortage of resources. This showed that equipping the college with ICT was not enough for attaining educational goals but empowering teachers with ICT knowledge and skills.

On the other hand, Cabero (2010) recommended that students should also participate as new educational agents. Cabero asserted that students have become a major element for communication and social interaction as a result of being born in a high-technological society. Thus, it can be stressed that pupils can play an active role in the use of ICT in the teaching and learning process because of their familiarity with the new technologies. Tello (2007) emphasises that the current situation shows that access to ICT is a major requirement for participation in a technological society. If students who are born in this high technological society can be allowed to participate in the learning and teaching process, then we would be closer to attaining quality education.

The study by Tezci (2010) showed teachers low levels of ICT (software) use for educational purposes in classroom was limited, and might have be strongly influenced by a lot of factors. The findings further revealed that teachers' factors that attributed to low use of ICT in classroom; low levels of teachers' experiences with ICT, low levels of expertise and lack of knowledge, and skills about how to use and adapt ICT in the education programs.

Tezci (2010) argues that there is a significant correlation between the levels of knowledge about ICT and the use of ICT in education. His study revealed that the higher the level of knowledge on ICT, the higher its level of use in education. It is imperative that teachers should receive training on the effective strategies and tools that can allow technology integration into classrooms (Almekhlafi and Almeqdadi, 2010) and improve curricula with technology-boosted materials (Goktas, Yildirim, and Yildirim, 2009; Hutchison and Reinking, 2011).

Anderson (2006), Bove´e, Voogt and Meelissen (2007), İşman, Evirgen and Çengel (2008), Paraskeva, Bouta and Papagianni (2008) in their research on ICT, the higher the mean level of knowledge, the more the ICT use. Teachers with previous computer experience have higher levels of knowledge on ICT and their ICT use is more frequent. Teacher's levels of ICT use show that they use these technologies as information transmission-based tools.

Sarangi (2003) and Alkahtani (2017) whose study revealed that educators had a limited idea about how the available ICT equipment could be used in teaching-learning situation. Their findings were attributed to the poor training opportunities for teachers to develop the necessary ICT skills.

2.10. Conclusion

Most of the literature reviewed showed that even though genetics has been identified; as being difficult to teach and learn in school, teachers use of poor teaching methods, lack of teaching and learning aids, recording poorly at national examinations and its concepts being too abstracts, few studies have taken interest in addressing these challenges. Further, there are few studies that have been undertaken to bridge the gaps between the traditional approaches and new technological methods in the teaching and learning of genetics. Furthermore, lack of teaching and learning aids and how to make the abstract concepts of genetics more user friendly to learners of genetics in secondary schools were among the issues that were raised. Thus, the study intended to use the ICT tool to address all these challenges so as to improve academic performance in genetics and also review if ICT tools can enhance learners (pupils) performance when it is used as a supplement to traditional teaching and learning methods.

Further, the literature that was reviewed mostly focused on the use of ICTs in education and its implication on the learners and teachers' attitude. However, these studies have not looked at the specific topics in biology and how appropriate ICT tools could be used to enhance learning and improve the attitudes of teachers and pupil. Finally, the studies in the literature reviewed that integrated ICT in the teaching and learning process used either qualitative or quantitative approaches, few studies have used mixed method design for their studies. The use of qualitative or quantitative approaches provides biasness in the results as both of the approaches show limitations when used independently in the research such that certain aspects might not be addressed very well. The current study whoever used the mixed method approach so that the weaknesses that are conferred by the qualitative approach can be supplemented by the quantitative approach and vice versa. Furthermore, current study used an experimental design for pupils with the Solomon Four Group design while in some of the literature reviewed, few researchers used experimental designs with specific ICT tools that determined the effects on pupils' attitudes and performance in genetics.

Even though there are many studies that have been done on integrating ICT in education, few studies have investigated the effects of integration specific ICT tools (video, gene X simulation software and Microsoft excel) in the teaching and learning of genetics.

CHAPTER THREE: METHODOLOGY

3.1. Overview

The researcher in this chapter described the methodology that was used in the study. The chapter was organised under the following sections: research design, study site, target population, sample size, sampling technique, data collection instruments, validity and reliability, data collection procedure, data analysis and ethical considerations.

3.2. Mixed method approach

According to Creswell (2015: 2) a mixed method research is;

> *"An approach to research in the social, behavioural, and health sciences in which the investigator gathers both quantitative (closed-ended) and qualitative (open-ended) data, integrates the two, and then draws interpretations based on the combined strengths of both sets of data to understand research problems."*

The researcher used a mixed method approach which mitigated limitations and biases found in both the qualitative and quantitative approaches because the two approaches have their own weaknesses and strengthens. Kombo and Tromp (2006) explained that the mixed method approach maximises the strengths and minimises the limitations of both qualitative and quantitative approaches. This enabled the researcher to be confident that the approach used would yield good results for the study.

According to Creswell (2009) there are six types of mixed method approaches, which are: sequential explanatory design, sequential exploratory design, the concurrent embedded design, concurrent triangulation design and the sequential transformative design. The researcher considered the concurrent triangulation design which is also known as convergent parallel mixed method design to be the best for this study. Creswell (2002, 2003, 2009 and 2012) had consistently revealed that this design is one of the most popular and effective in educational research. The design enabled the researcher to collect and analyse both qualitative and quantitative data concurrently and then have the two data bases merged for comparison to determine if there will be convergence, differences or some combination (Creswell, 2009).

Using the design in Figure 3.2. the researcher was able to find out if ICT tools (Excel, videos, Gene X simulation software) enhanced pupil performance in Genetics in Biology at two selected schools in Kitwe district when it was used as an enhancement to traditional teaching learning method, to determine the impact of ICT on pupils' performance in genetics, to explore the attitude of teachers and pupils on the use of ICT tools in the teaching and learning of genetics. The researcher was of the view that using the data that was collected, research objectives and questions would be addressed. The Figure 3.1. illustrates how the concurrent triangulation design or convergent parallel design was applied in the study.

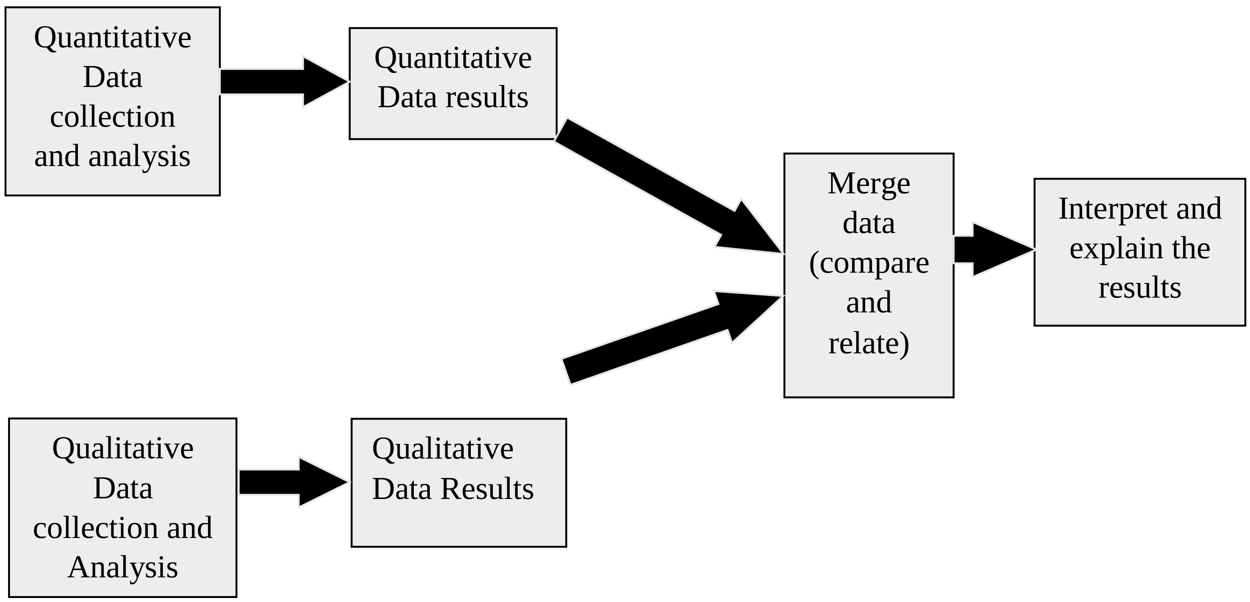


Figure 3.1. Concurrent Triangulation Design (Convergent Parallel Mixed Method Design) illustration

SOURCE: Adapted from Creswell (2014:269)-----------------------------------

3.3. Study area

This study was conducted at two selected core secondary schools in Kitwe district. The reason for selecting core secondary schools was that the researcher was aware of the importance of gender (male or female) in secondary schools and wanted to establish the impact of ICT tools on gender. Further, biology was taught in all secondary schools, at senior secondary and these schools had computer laboratories that were need for the study. Thus, the researcher expected not to find challenges in collecting data from the rightful respondents.

3.4. Study population

Bryman (2001) defined the word population as a group of elements or causes whether individuals, objects or events that conform to specific criteria and to which the research intends to generalise its results. In other words, a population is a total number of objects or people from which the sample for a particular study is selected from (Kombo and Tromp, 2006). The study targeted all teachers and grade 12 pupils of biology at secondary schools in Kitwe District.

3.5. Study sample

The Australian Bureau of Statistics (2004) indicated that the purpose of sampling in any research work is to overcome the problem associated with the vastness of the study population. Therefore, the sample was made up of 202 randomly picked grade 12 pupils and teachers of biology from two different schools. The sample size was larger than what could be expected from a population of 500 because findings based upon a larger sample have more certainty than those based on smaller ones. Similarly, Best and Khan (2006) defined an ideal sample as a number that is large enough to serve as an adequate representation of the population which the researcher wishes to generalise and small enough to be selected economically in terms of subject availability and expense in both time and money. Best and Khan (2006) have argued that an ideal sample size may depend on the nature of the population and the type of data that needs to be collected and analysed. It is for this reason that every researcher needs to come up with a good and manageable sample representation of the population. Therefore, to arrive at the study sample, the researcher employed the Yamane formula for determining the sample size. Yamane (2015) devised a formula of determining a sample size of the population for a study. The formula below by Yamane was used to determine the sample size for this study.

$$n = \frac{N}{1 + N(e)} 2$$

N= population size, n= corrected sample, e = margin of error (MoE), e =0.05 based on research condition.

In this study, N= 310, at 5% of MoE, at 95% confidence level and p= 0.5

$$n = \frac{310}{1+310(0.05)} 2$$

$$n = \frac{310}{1+310(0.0025)}$$

$$n = \frac{310}{1+0.775}$$

$$n = \frac{310}{1.775}$$

$$n = 174.648$$

$$n \approx 175$$

sample size will be 175 respondents

From the calculations, the sample size for this study was 175 respondents. However, during the study, the sample size was 202 which was broken into 10 teachers and administrators of biology. Then, 192 grade 12 pupils were randomly stratified in 4 classes. The sample size for pupils was larger than what was expected from the initial population sample. According to Kumar (1996) the larger the sample size, the more accurate the findings. Thus, larger sample sizes have higher certainties than smaller sample sizes.

3.6. Sampling technique

Both non-probability and probability sampling techniques were used in this study. According to Bernard (2002) purposive sampling is a type of non- probability sampling that is most effective when one needs to study a certain cultural domain with knowledgeable experts within. In purposive sampling, the researcher decides on what needs to be known and targets people who can and are willing to provide the information by virtue of their knowledge or experience (Bernard, 2002; Lewis and Sheppard, 2006). Thus, the study employed purposive sampling in the selection of Secondary schools, teachers and administrators of Biology in schools. Bearing in mind different types of purposive sampling, the researcher used specifically homogeneous purposive sampling. Kombo and Tromp (2006) referred to this type of purposive sampling as homogeneous because it aims at picking a small sample with similar characteristic in order to describe some particular subgroup in depth. Thus, only learners (pupils) who study biology and teachers of biology were respondents in the study.

Simple random sampling was used in both selected two secondary schools. Since the respondents (pupils) were from Core-Secondary Schools, a stratified random sampling was used to come up with two strata, male and female. This was to ensure gender balance so as to minimise prejudice and biasness in the study. This also may have provided a platform where certain subgroups in the population may be represented in the sample in proportion to their population (Kombo and Tromp, 2006). As earlier stated, the sample comprised of 10 teachers of biology and 192 grade 12 pupils from the two secondary schools in Kitwe District, on the Copperbelt province of Zambia.

3.7. Data collection instruments

According to Kombo and Tromp (2006) questionnaires, interview schedules, observation and focus group discussions are the most commonly used research instruments. The researcher in this study used the Pretest-posttest tests, face to face interview guide, focus group discussions, and structured attitude questionnaires, were used to collect data. It was prudent to use three different instruments of data collection as a way of ensuring validity and credibility of the research findings.

3.8. Data collection procedures

The researcher requested for permission from District Education Board Secretary (DEBS) for Kitwe district and from two secondary schools Managers. This was done in order for the researcher to be given permission to freely interact with the selected respondents without any interference. The researcher also asked for consent from the respondents by explaining the purpose of the study so as to enable them make an informed decision on whether to participate in the study or not. Since respondents comprised male and female, the order of administering the research instruments was guided by the sampling techniques described in section 3.6 so that each respondent is given chance to be part of the study.

All in all, using the research instruments prepared, the researcher managed to interview and distribute questionnaires to the sampled respondents. He had to introduce the topic and got various respondents' views so as to discuss in more detail the integration of ICT in the teaching and learning of genetics.

3.8.1.Quantitative data collection procedure

The pupils and teachers were distributed in groups as shown in Table. 3.1.

Table 3.1. Status of Questionnaire Distribution and Return

Types of respondents	Number of questionnaires distributed	Number of questionnaires received for analysis	% of received questionnaires for analysis
Pupils	192	186	96.9%
teachers	10	10	100.00%

Table 3.1 presents the general status of the questionnaires that were distributed and later received after filling in by the respondents. As seen from the Table 3.1, 192 questionnaires were distributed to grade 12 pupils who were selected as respondents in the research and 10 questionnaires were distributed to teachers of biology. 186 (96.9%) managed to return the questionnaires and 10 (100%) teachers returned the questionnaires. This means that 186 and 10 questionnaires meant for pupils and teachers were analysed respectively. The description of how the respondents were selected is what is described in the following section.

Then, pupils from four group names were distributed as shown in Table 3.2.

Table 3.2. Status of Pretest and Posttest Distribution

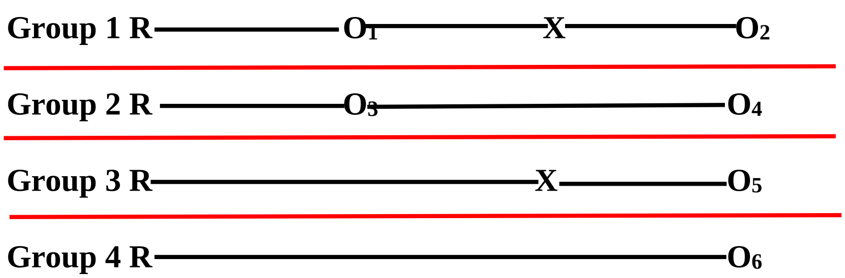
Types of respondents	Number of Pretest scripts distributed	Number of pretest scripts received	% of received scripts posttest	Number of Posttest scripts distributed	Number of posttest scripts received	% of received scripts posttest
Experimental group 1	45	45	100%	45	45	100%
Control group 1	55	55	100%	55	55	100%
Experimental group 2				49	49	100%

Control group 2	43	43	100%

Table 3.2. presents the general status of the pretest and posttest that were distributed and later received for marking from respondents. As seen from the Table.3.2, all respondents returned the scripts in the pretest and posttest for marking. This meant that 100% returned test scripts were analysed by the researcher. The description of how the respondents were selected is what is described in the following section.

Solomon Four-Group design

According to *Creswell (2014)* Solomon Four-Group design is a special case of a 2 X 2 factorial design that involves random assignment of respondent to four groups. The pretest and posttest are varied for four groups. All groups received the posttest. The Figure 3.2. illustrates how the Solomon Four-Group design was used in the study.



Figuere.3.2. Solomon Four-Group Design

Source: adopted from Creswell (2014:221)

0 =represents the observations or measurements recorded (Pre-test or Post-test scores) on instruments

X= represented the exposure of the group to the treatment (ICT tools interventions)

R= represented the random assignment of respondents (pupils)

—— = represented that the comparison groups were not equal (equated) by random assignment.

Solomon Four-Group design (Figure 3.2) was used to collect quantitative data over a period of seven weeks using ICT as intervention to supplement for the traditional teaching and learning approach.

The ICT tools (Gene X simulation software, videos and excel) were used on different sub-topics to teach genetics under the following headings:

1. Describe cell division (mitosis and meiosis) using videos and simulations models (laboratory work)
2. Describe and demonstrate variation using excel (laboratory work).
3. Describe the basic introduction to the central dogma (DNA replication-transcription-translation) using a video and Gene X simulation software.
4. Describe and demonstrate the inheritance of monohybrid traits videos and simulations models (height, eyes colour, earlobes).
5. Describe inheritance of sickle cell anaemia and albinism using Gene X simulation software and videos simulations.
6. Describe the inheritance of sex-linked traits (colour blindness and haemophilia) using Gene X simulations software and videos simulations.
7. Describe and demonstrate mutation using the Gene X simulation software and video simulations.

The lessons on the outlined headings were done per week and collected data was analysed depending on the activity schedule. They were four groups of pupils: two experimental groups and two control groups. In the first week, all four groups learnt genetics based on the Zambian Secondary Biology Syllabus (ZSBS) using traditional learning approaches, in particular, lecture methods, simple demonstrations and books. After that, the groups 1 and 2 were pre-tested. Then, the experimental groups (group 1 and 3) started learning more about genetics using ICT tools. Each pupil in the experimental groups (groups 1 and 3) had access to a laptop computer or desktop computer for the purpose of learning, and a projector was provided as an alternative to computers for discussing video simulations.

However, groups 2 and 4 (control groups) continued learning using traditional learning approaches. In case of any difficulties, both groups had the same amount of time to ask the teacher for help.

At the end of the lesson, all the groups were tested (post-tested) as shown below in Figure 3.2. using the same questions. Due to the limited number of objectives on the biology syllabus, each test contained 20 multiple questions subdivide into two sections (10 questions for each section). The test was done in 30 minutes. The duration was based on the biology 5090 paper 1 past examination papers were the questions come from 40 multiple choice questions, and pupils are expected to be done with the examination in 60 minutes. This implied that the 20 questions had to be done in 30 minutes (ECZ, 2013, 2014, 2015, 2016).

The four groups had different experiences:

1. group 1 had a pre-tested, a treatment and was post-tested.
2. group 2 had a pre-tested, no treatment and was post-tested.
3. group 3 had no pre-tested, but had a treatment, and was post-tested.
4. group 4 had no pre-tested, no treatment, but was post-tested

3.8.2. Qualitative data collection procedure

The researcher began by administering pupils' attitude questionnaires in all pupils in the Group-names (experimental and control groups) using the Solomon Four-Group design as a guide. This was done so that pupils attitudes towards ICT use in genetics could be determined. Secondly, teachers' attitude questionnaires were administered to teachers of biology in the two secondary schools so that their attitudes towards the use of ICT in genetics can be determined.

Thirdly, the researcher conducted the face to face interviews with 10 teachers of biology. Each of the 10 teachers were interviewed independently on the same day. 6 teachers were from one school and the other 4 teachers from the other school since the researcher targeted only two schools. Each face to face interview lasted for 15 minutes.

And finally, focus group discussions were conducted with 10 pupils from each of the four Group-names and the interactions were lasting for 20 minutes. This was to ensure that the pupils exhausted their inputs during the discussions.

This was done so that the researcher could compare the responses of both pupils and teachers of biology on the attitudes using ICT in the teaching and learning of genetics.

3.9. Data analysis instruments and procedures

Data analysis refers to "examining what has been collected in a survey or experiment and making deductions and inferences. It involves uncovering underlying structures; extracting important variables, detecting any anomalies and testing any assumptions" (Kombo and Tromp, 2006: 117).

3.9.1. Quantitative Data analysis

In this study, the data that was collected from the true-experimental design (Solomon Four-Group design) was analysed through the use of Statistical Package for Social Sciences (SPSS) version 20 where descriptive and inferential numeric analysis were used. Results from the Solomon Four-Group design was analysed using a Campbell and Stanley 2 X 2 design analysis as shown in Table 3.3. Then, the researcher used specifically frequencies, measures of central tendency (mean [M]), Standard deviation (SD) and inferential statistics

3.9.2. Measure of central tendency and dispersion

Means and standard deviations were used to analyse pretest and posttest genetics scores for pupils, teachers' and pupils' attitude questionnaires.

3.9.3. Inferential statistics

The t-tests [paired sample and independent t-tests] used to measure pretest and posttest comparison within the groups (group 1 and 2) and between groups (group 1 and 2) respectively. These two groups were subjected to the pretest and posttest. One-way ANOVA was used to measure the performance of pupils in genetics using posttest scores in all four Group-names. It was also used to measure the scale data (attitude mean scores) for pupils' attitude questionnaire in all four Group-names. Factorial AVONA was used to compare how two independent (gender and age, Group-names and age, and group-names and gender) variables were impacting on pupils' performance when using ICT in genetics using posttest scores.

Table 3.3: Campbell and Stanley 2x2 design Analysis (Solomon four design analysis)

Types of score	**No treatment**	**Treatment**
Pretested scores	0_4	0_2
Unpretested scores	0_6	0_5

Source: Campbell and Stanley (1963)

Furthermore, to analysis the attitude of teachers on the use of ICTs in the teaching and learning of genetics, the 6-Likert type set of questions that were asked requiring the respondents to indicate their levels of agreement with the statements, Descriptive statistics and Mann-Whitney U test were used. The Mann-Whitney U test was used to measure the effect of ICT use on gender in teachers using teachers' attitude mean scores. The teachers' attitude questionnaires were transformed from ordinal data into mean attitude score (scale data) using SPSS for the purpose of analysing data using quantitatively (Morgan e'tal, 2011: 83).

Finally, to analysis the attitude of pupils on the use of ICTs in the teaching and learning of genetics, the 6-Likert type set of questions that were asked requiring the respondents to indicate their levels of agreement with the statements, Descriptive statistics and one-way ANOVA were used. The pupil's attitude questionnaires were transformed from ordinal data to mean attitude scores (scale data) using SPSS for the purpose of analysing data using quantitatively (Morgan e'tal, 2011: 83).

3.9.2. Qualitative data analysis

Miles and Huberman (1994) documented that data analysis in the qualitative model comprises three levels of activities which are: data reduction, data display and conclusion drawing or verification. Slightly different from the views of Miles and Huberman (1994), Sjostrom and Dahlgren (2002) in their study revealed that qualitative analysis involves seven key steps which are: familiarisation, compilation of answers from respondents, condensation or reduction, preliminary comparison or classification, naming of categories and contrastive comparison of categories. Thus, qualitative data that was collected from some questionnaires and interviews were analysed from the seven steps cited above and were coded into emergent themes and grouped into categories (Creswell, 2009). This implies that the researcher used description and thematic analysis in analysing qualitative data to have the research questions answered

The first step was familiarisation, the researcher read through all the collected data so that to understand and make necessary corrections by getting back to the actual respondents or recorded data. After step one was done, the next step involved compilation of responses from participants, where vital responses were considered. In the third step, the researcher tried to condense or reduce individual responses by finding the central parts of dialogue. Upon addressing step three, the researcher went into preliminary grouping or classifying responses that sounds to be similar. What exactly followed after classification of similar answers were preliminary comparison of categories by the researcher. When the categories were clearly compared, the researcher went to the sixth step which involved naming of categories which Creswell (2009) called coding. The seventh step was contrastive comparison of categories where the description of the characters of each category and similarities between categories were done in order to come up with similar emerging themes (Sjostrom and Dahlgren, 2002).

The process was conducted for both teachers and pupils face to face interviews and group discussions in coming up with the theme respectively.

Finally, quantitative results were compared with qualitative results before a conclusion was drawn. It was the wish of the researcher that through this analysis of data, a rational and fairly well informed assessment of integrating ICT in the teaching and learning of genetics in the selected secondary schools in Kitwe District was addressed.

3.10. Validity and reliability

3.10.1. Validity

The aspect of validity examines the extent to which the results of the study could be generalised to the real world (Achola and Bless, 1988). Correspondingly, Mulenga (2015) explained that validity is the degree to which results obtained from the analysis of data represent the phenomenon under study. In other words, research findings are said to be valid if the research carried out depicts and brings out what it purported to bring out. One of the approaches of validating research findings is to use multiple methods of data collection. This is supported by Brewer and Patton (2002) who argued that the combination of methods complement each other by eliminating overlapping flaws. Besides, when methods are combined, which is known as triangulation, inconsistencies are taken care of, thus valid and reliable data emerges (Patton, 1990). In order to validate the findings in this study, the researcher recorded each and every interview during data collection so as to check for unclear information and then cross check with the respondents. During cross checking, the researcher made use of the responses for the verification of the findings and be able to make follow ups on issues that needed clarity. In addition, the researcher was able to compare the findings from the interviews, observation schedules and questionnaires in order to check whether the analysed data represents the phenomenon under study.

In this study, the content of validity of the tests were confirmed by matching the test questions to specific objectives as required by the CDC 5090 biology curriculum. An experimental design (Solomon four group design) was to obtain data, this method is so strong that when it is used, many common threats to internal validity are controlled (Cohen and Manion, 1990).

Since the same questions were used for pre-tests and post-tests, pupils in control group 1 and experimental group 1 were pre-tested and the results were compared using an independent sample t-test. The results showed that both groups were similar before the start of the experiment as there was no significance difference between the mean scores of the groups (Table 4.1.1). however, the testing effect, if any, affected all the respondents equally, and so any significant improvement above the control groups could not be attributed to the testing effect but to the use of ICT tools. Furthermore, control and experimental groups 2 were not subjected to the pretests, but post-tests only.

During the study, the ICT as well as the researcher's manner of data collection and recording did not change. This helped to eliminate the effect of instrumentation. Further, only one researcher took note of the results. This also helped to eliminate the effect of instrument delay.

In order the avoid the problem of differential selection, random assignment was used. Thus, nay person in the respondent pool had an equal chance of being assigned to either the experimental or control groups. Therefore, the outcome of this study was a function of the treatment being evaluated and not the initial differences between the groups.

Another threat to internal validity is experimental treatment diffusion. It can happen if the experiment and control groups are very close to each other during the experiment. The treatment may diffuse to the control group and so the effect of the treatment on the post-test would be confounded. In the study, diffusion was avoided by arranging condition in such as a way that the experimental and control groups in one school were attending classes differently. In school A, the experimental group pupils that were attending classes in the morning sessions, while the pupils in the control group were attending classes in the afternoon sessions (Assessment of Performance Unit) [APU]. In school B, pupils in the experimental group were attending classes in the afternoon sessions, while pupils in the control group pupils were attending classes in the morning sessions. Furthermore, the school A and School B were geographical isolated from each other. This means that the two schools were further apart from each other that chances for treatment diffusion were slim. This helped to take care of experimental treatment diffusion.

An additional problem with the design that was used was the possible interaction effect. To ascertain that there were no interaction effects, the factorial analysis (two-way ANOVA) was used. The results showed that there were no interaction effects that between gender and age group, gender and group names, and age group and group names as shown on Table 4.9., Table 4.12 and Table 4.14 respectively.

In order to maximise the external validity, the respondents that were selected were a good extent a representative of the population to which the researcher chose to generalise his findings.

3.10.2. Reliability

The accuracy precision of a measurement procedure of research instruments is commonly known as reliability (Thorndike, 1997; Mugenda and Mugenda, 1999 and Creswell, 2012). Mugenda and Mugenda (1999) looked at reliability as the degree to which a research instrument yields consistent results or data after repeated trials. To ensure reliability, thirty (30) attitude questionnaires and pretest and post-test test were piloted at Mukuba University, Kitwe district. Further, expert review of the instrument was conducted so as to ensure that the instruments were of high standard and would yield consistent results after repeated trials.

In addition, Blair and Czaja (2014) asserted that if the questionnaire is not well developed, it tends to have a high probability of making the researcher collect inaccurate data. This would paralyse the whole essence of the research to be carried out. It was in this view that questionnaires were pre-tested in order to assess whether the instruments address the following key questions:

(i) Are the questions contained in the questionnaire measuring what they are supposed to measure?

(ii) Do the questions provoke a response?

(iii) Is there any researcher bias?

(iv) Is the wording clear and do different respondents interpret the questions in the similar way?

The questions that were cited enabled the researcher to evaluate whether the questionnaires were clear and specific.

Further the study was expert reviewed so as to enable the researcher to make amendments on the research instruments so that appropriate data was collected.

Finally, the Cronbach's alpha reliability test for pupil's attitude questionnaire was α=0.87 while for the teacher's attitude questionnaire, it was α= 0.68. Cronbach's alpha is used to measure the internal consistence of the items in the scale. Looking at the Cronbach's alpha levels for both attitude questionnaires, the questionnaires were reliability for the study. However, the teacher's attitude questionnaire's Cronbach's alpha was weaker than the pupil's attitude questionnaires' Cronbach's alpha value that was much closer to α=1, showing a good reliability.

3.11. Ethical considerations

The term ethics or ethical means 'in accordance with principles of conduct that are considered correct, especially those of a given profession or group' (Kumar, 1999). Considering the significance of ethical issues in every research, all responses from respondents, names, research sites and any related identities that may have led to avail identity or research site in this study was treated with maximum confidentiality as the data was used purely for this academic exercise. Thus, anonymity was observed by the researcher.

Finally, informed consent was sought from all respondents/participants (pupils and teachers) by informing them what the study was all about. This guided the respondents/ participants to decide on their own whether to participate in the study or not. Permission was also sought from the Post graduate assistant Dean in the School of Education, and Kitwe District Education Board Secretary (DEBS) for the researcher to freely visit the two selected secondary schools and interact with teachers of biology and pupils in a friendly manner.

CHAPTER FOUR: PRESENTATION OF FINDINGS

4.1. Overview

In this study, the researcher collected enough data. The analysis of data was guided by the information which addressed the research questions below:

i. How does ICT tools (Excel, videos, Gene X. 2.0 simulation software) enhance pupil performance in Genetics in Biology at two elected schools in Kitwe district when it is used as an enhancement to traditional teaching learning methods.

ii. What is the impact of ICTs on pupils' (gender and age group) performance in genetics?

iii. What are the attitudes of pupils on the use of ICT in the teaching and learning of genetics?

iv. What are the attitudes of teachers and pupils on the use of ICT in the teaching and learning of genetics?

The data analysis and presentation was done using the research instruments results and according to the research paradigm mixed method approach (concurrent triangulation design). Thus, data analysis was analysed according to whether it was quantitative or qualitative data. Finally, the findings were presented according to the research questions and the type of data that was analysed.

4.1.1. Quantitative data analysis and results

This section analysed data for research questions, i, ii, iii and iv using Data collected using descriptive and inferential statistics (paired-sample t test, independent-sample t tests, one way-ANOVA, two-way ANOVA [factorial analysis] and Mann-Whitney U test).

4.1.2. Research question one

The study provided answers to the research question 1: To find out if ICT tools (Excel, videos, simulations) enhance pupil performance in Genetics in Biology at two elected schools in Kitwe district when it was used as an enhancement to traditional teaching learning methods.

Data collected using this research was analysed using descriptive and inferential statistics (paired-sample t test, independent-sample t tests, one way-ANOVA. A paired sample t-test, independent t-tests and one-way ANOVA were used to evaluate whether a statistically significant difference existed between the mean genetics scores before (pretest) and after (posttest) an intervention (treatment) in genetics between experimental and control groups.

4.1.3. Performance of pupils who were pretested in experiment and control groups 1

Table 4.1. below shows the independent t-test mean score and t-values for pretest scores in experimental and control groups 1 before the intervention was introduced in the experimental group. This was administered to ascertain the equivalence of groups (experimental and control groups).

Table 4.1. Mean and t-values of pretest for experimental and control groups 1 and 2

Group names	N	M	SD	t	df	p	d
control group 1	55	45.40	20.97	2.78	92.46	0.006	0.55
experimental 1	45	55.00	13.23				

**The t and df were adjusted because variance were not equal, F=17.83, p<0.001*

Levene's test (F) for the assumption that the variances of the of two groups are equal. If the F test is not significant (Sig >0.05), the assumption is not violated and one uses the 'equal variances assumed (EVA) line for the t tests and related statistics. However, if the Levene's F is significant (Sig <0.05), the equal variance not assumed (EVNA) line is used. Levene's test (F=17.83, p=0.01) is statistically significant, therefore, variances are significantly different and the assumptions of equal variances is violated. Thus, the equal variances not assumed and the descriptive Mean of scores in genetics scores were used.

The pretest mean scores of experimental and control groups 1 were 55.00 and 45.40, respectively on the pre-test. It was found that both groups were similar before the start of the experiment as there was no significant difference between the mean scores of groups.

4.1.4. Performance of pupils within groups that were exposed to pretest and posttest

The Table 4.2. below shows means and t-test value on the scores of pretest and posttest of group 1 (experimental group 1).

Table 4.2. Means, standard deviation and t-values scores of pretest and posttest

Group 1	N	M	SD	t	df	p	η^2
pretest	45	52.00	15.00	28.82	44.00	0.000	2.21
posttest	45	74.67	12.59				
**the p-values was measured at the significant level of p=0.05*							

Table 4.2. shows the results of the paired sample t-test were significant, t (44) = 28.82, p<.001, η^2 =2.21, indicating that there was a significant increase in genetic test scores from the pretest (M =52, SD = 15.54, N=45) to the posttest (M = 74.67, SD = 12.59), and the effect size was large based on Cohen's convention (1988). The mean difference between the pretest and posttest scores was 22.67. It can be concluded from the results shown in Table. 4.1.4a. that the differences found between the two sets of scores were due to the treatment, and not to chance.

Table 4.3. below shows means and t-test value on the scores of pretest and posttest of group 2 (control group 1).

Table 4.3. Means, standard deviation and t-values scores of pretest and posttest

Group 1	N	M	SD	t	df	p	η^2
pretest	55	33.33	14.84	-3.91	54	.000	1.01
posttest	55	47.55	17.79				
**the p-values was measured at the significant level of p=0.05*							

Table 4.3. shows that the results of the paired sample t-test were significant, t (54) = 3.91, p<.001, η^2 =1.01, indicating that there a significant increase in genetic scores from the pretest (M =33.33, SD = 14.84, N=55) to the posttest (M = 47.55, SD = 17.79), and the effect size was large based on Cohen's convention (1988). The mean difference between the pretest and posttest scores was 14.23.

The results show that there was a significant increase in the learners' achievement in the control group 1. However, the mean difference was significantly higher in experimental group 1 (22.67) than in control group 1(14.23) which was 8.44. The difference in means between experimental group 1 and control group 1 can be attributes to the intervention that was introduced after the pretest in in experimental group 1.

4.1.5. Performance of pupils in experimental and control groups 1 that were exposed to posttest

Therefore, in order to get the differences in mean scores in experimental group 1 and control group 1 after the intervention, an independent t-test was applied to the ascertain if ICT tools enhanced pupils' performance in genetics. The Table 4.4. below shows the means standard deviation and t-test value of posttest in experimental group 1 and control group 1.

Table 4.4. Means, standard deviation and t-values scores of posttest

Group names	N	M	SD	t	df	p	ŋ^2
control 1	55	46.09	16.88	-9.69	97	.000	1.92
experimental 1	45	74.67	12.59				

**The t and df were adjusted because variance were not equal, F=*4.85*, p=.03 (<.05)*

Table 4.4. shows that experimental group 1 was significantly different from control group 1 [t (97) = 9.69, p<0.001]. Inspection of the two groups show that the average mean genetics achievement scores for control group 1 learners (M=46.09) is significantly lower than the score (M= 74.67) for experimental group 1. Table 4.4. shows that the difference between the means is 28.57. The effect size d is 1.92, which is the large effect size according to Cohen (1988). The comparison of the experimental 1 and control 1 groups also show that there is an improvement in performance of genetics scores when ICT tools are used in the teaching and learning of genetics than when traditional methods are used in the teaching and learning and teaching of genetics.

4.1.6. Performance of pupils within groups that were exposed to posttest only

To show that pretest did not have an influence on the performance of the experimental group 1 and control group 1, another independent sample t-test was conducted between experimental group 2 and control group 2. The groups were not pretested so any difference between the means will be attributed mainly to the intervention (ICT tools integration) in the teaching and learning of genetics, and not to the effect of the pretest. The Table 4.5. below shows the mean, standard deviation and t-test value of posttest in experimental group 2 and control group 2.

Table 4.5. Means, standard deviation and t-values scores of posttest

Group names	N	M	SD	t	df	p	η^2
control 2	43	48.84	14.59	-5.96	86	.000	1.22
experimental 2	45	68.89	18.12				

**The t and df were not adjusted because variance were equal, F=*1.09*, p=*.298 *(>.05)*

Table 4.5. shows that the experimental group 1 is significantly different from control group 1 [t (86) = 5.96, p<0.001]. Inspection of the two groups show that the average mean genetics achievement scores for control group 2 learners (M=48.84) is significantly lower than the score (M= 68.89) for experimental group 2. Table 4.5. shows that the difference between the means is 20.05. With the effect size d is 1.22, which is the large effect size according to Cohen (1988). The comparison of the experimental 2 and control 2 groups also show that there was an improvement in performance of genetics when it is taught with ICT than when it was taught using traditional method approach.

4.1.7. Performance of pupils in genetics across all group names

One-way ANOVA was used to assess the performance of all the groups in genetics. Table 4.6. and Table 4.7. below shows the mean, standard deviation and t-test value of posttest score across all group names.

Table 4. 6. Means, standard deviation and t-values scores of posttest across all groups

Group name	N	M	SD
control 1	55	47.55	17.79
control 2	43	48.84	14.59
experimental 1	45	74.67	12.59
experimental 2	49	69.18	17.51
Total	192	59.71	19.87

Table 4.7. t-values scores of posttest across all groups.

	df	F	p	d
Between Groups	3	36.36	.000	.000
Within Groups	188			
Total	191			
**The t and df were adjusted because variance were equal, F=2.34, p=.075 (>.05)*				

Table 4.6. indicated that there was an increase in in means for experimental 1 and 2 (M= 74.67 and 69.18) respectively with the highest mean shown in the experimental group 1. While the control groups 1 and 2 showed the significantly lower means M= 48.55 and 47.55) with the lowest mean shown in control group 1.

Table 4.7. indicated that the ICT tools that were integrated in the teaching and learning of genetics had a significant impact on learners' performance in genetics when used as an enhancement with traditional method of teaching, F (3, 188) =36 36, p<0.001. Thus, the first null hypothesis was reject (H_{o1}) and the alternative hypothesis (H_{A1}) was accepted. There is a significant difference in pupils' performance when ICTs are used as enhancement tools to traditional teaching and learning of genetics. This implied that genetics scores or performance differed for different groups (control 1 and 2 groups, and experimental 1 and 2 groups).

Table 4.8.: Post Hoc homogenous subset for posttest scores in all group names

Group name		N	Subset for alpha = 0.05	
			1	**2**
Tukey HSD[a,b]	control 1	55	47.55	
	control 2	43	48.84	
	experimental 2	49		69.18
	experimental 1	45		74.67
	Sig.		.979	.338

The assumptions of the homogenous subset states that:

1. Groups that are listed in the same subset are not significantly different
2. Groups that are not listed in the same subsets are significantly different

Table 4.8. shows that groups (experimental groups 1 and 2) are listed in the same subset and are not significantly different. Thus, the performance of pupils in genetics for those in experimental group 1 were not different from those pupils in the experimental group 2 when ICT tools were used in the teaching and learning of genetics. And pupils' performance in control group 1 were also not different from those pupils in control group 2. However, the mean scores for experimental groups 1 and 2 groups were significantly higher than the mean score for control groups 1 and 2. Therefore, genetics posttest performance showed the highest mean performance in learners that integrated ICT tools in the teaching and learning process as opposed to those that learnt using traditional methods as shown in Table 4.8. The results also showed that experimental 1 and 2 groups were significantly different from control 1 and 2 groups. It can finally be concluded that integrating ICT tools in the teaching and learning of genetics enhance academic performance in pupils when it was used as an enhancement tool to traditional teaching-learning approach of genetics.

4.2.1. Research question two

The study provided answers to the research question 2: What is the impact of ICTs on pupils' performance in genetics as a function of gender and age-group?

Two-way ANOVA (factorial ANOVA) was employed to compare groups based on two independent variables (gender and age-group). This statistic is used when there are two different independent variables, each of which classifies (or labels) participants with respect to a particular characteristic, with each participant being labeled by a particular level of each of the independent variables (completely crossed design) (Morgan, Leech, Gloeckner and Barrett, 2011). Individuals in this study were labeled, or classified, based on the variables of gender and age group, group names and gender, and group names and age. Thus, the research question tackled the following sub-headings; differences in genetics performance as a factor of gender and age, differences in genetics performance as a function of group and gender, and differences in genetics performance as a function of group and age group.

4.2.2. Differences in genetics performance as a function of gender and age group

Table 4.9: Mean comparisons for genetics post-test performance as a function of gender and age group

Age group	Male			Female			Total	
	n	M	SD	n	M	SD	M	SD
less than 17 yrs old	8	61.25	13.56	15	54.00	22.29	56.52	19.68
between 17-19 yrs old	79	62.47	19.84	73	57.81	20.83	60.23	20.37
above 19 yrs old	14	61.07	16.43	3	51.67	7.64	59.41	15.50
Total	101	62.18	18.85	91	56.98	20.71	59.71	19.87

In Table 4.9. The mean scores of 8 males (M=61.25, SD=13.56) below the age 17 years performed higher genetics than 15 females (M=54.00, SD=22.29) of the same age with the mean difference of 7.25. Further, the mean scores of 79 males (M=62.47, SD=19.84) between 17-19 years old performed slightly higher in genetics than 73 females (M=57.81, 20.83) of the same age with the difference of 2.24. The performance of 14 males (M=61.07, SD=16.45) in genetics aged above 19 years was also higher than 3 females (M=51.67, SD=7.64) with the difference of 8.4. Overall, across gender, the mean score performance of male pupils (M=62.18, SD=18.85) higher than female pupils (M=56.98, 20.71) with the difference of 5.2. And finally across age group, the pupils ranging between 17-19 years old (M=60.23, SD=20.37) showed a higher mean performance in genetics than those pupils below 17 years (M=56.52, SD=19.68) and above 19 years old (M=59.41, SD=15.50).

Table 4.10.: Factorial analysis of variance showing the genetics posttest performance as a function of gender and age group

Variable and source	df	MS	F	p	η^2
Gender	1	729.51	1.84	.18	.010
Age groups	2	114.07	.29	.75	.003
Age groups *gender	2	38.33	.097	.91	.001
Error	186	396.86			

Table 4.10. shows that there was not a significant difference interaction between gender and age group on genetics performance when ICT tools are used in the teaching and learning of genetics,

F (2, 186) =0.91, p= 0.91, ŋ^2 =0.001. It can be determined that the post test scores were not impacted by any interaction of gender and age groups. There was not a significant mean effect on gender and performance in genetics posttest scores when ICT tools are used in the teaching and learning of genetics, F (1, 186) =1.84, p= 0.18, ŋ^2 =0.010. Further, there was not a significant mean effect on age and performance in genetics posttest scores when ICT tools are used in the teaching and learning of genetics, F (2, 186) =0.29, p= 0.75, ŋ^2 =0.03. It can be concluded that the performance of male and female learners was not dependent on their age groups. Learners of experimental groups performed better irrespective of their age group level.

Estimate marginal means of genetics performance of posttest a function of gender and age

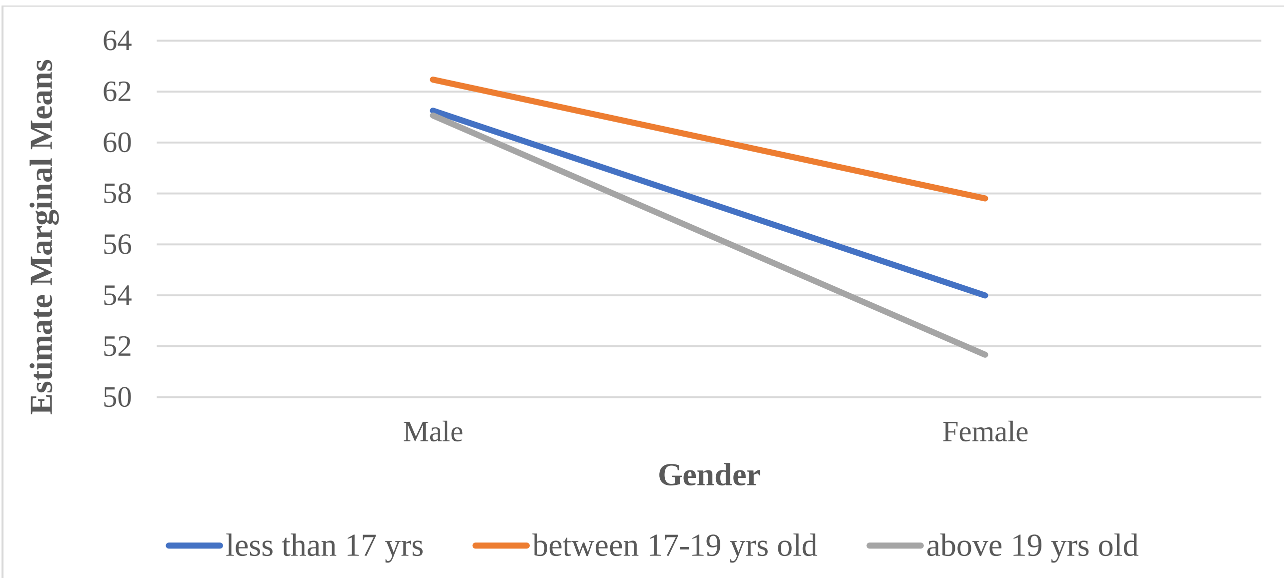


Figure 4.1.: Profile plot of estimate marginal means of genetics performance of posttest a function of gender and age

Figure 4.1. shows that males show the significant difference in performance across all age groups, while female don't show any significance difference in performance among themselves. Although the factorial analysis of variance shows that there was no significance difference in genetics performance as a function of age and gender, the genetics performance estimate mean plot shows the significant difference between male performance. Thus, there was an interaction between male performance in genetics especially those between the age of 17-19 years, and above 19 years old.

4.2.3. Differences in genetics performance as a function of group and gender

Table 4.11: Descriptive statistics mean comparisons for genetics post-test performance as a function of gender and group name

Group name	Male			Female			Total		
	n	**M**	**SD**	**n**	**M**	**SD**	**M**	**SD**	**N**
control 1	27	50.74	18.22	28	44.46	17.12	47.55	17.79	55
control 2	24	53.13	13.09	19	43.42	14.91	48.84	14.59	43
experimental 1	26	78.27	11.04	19	69.74	13.17	74.67	12.59	45
experimental 2	24	66.67	17.67	25	71.60	17.36	69.18	17.51	49
Total	101	62.18	18.85	91	56.98	20.71	59.71	19.87	192

In Table 4.11. The mean scores of 27 males (M=50.74, SD=18.22) in control group 1 performed higher genetics than 28 females (M=44.46, SD=17.12) of the same group with the mean difference of 6.28. Further, the mean scores for 24 males (M=53.13, SD=13.09) in control group 2 performed slightly higher in genetics than 19 females (M=48.84, 24.59) of the same group with the difference of 4.29. The mean performance score for 26 males (M=78.27, SD=11.04) in genetics for experimental group 1 was also higher for 19 females (M=69.74, SD=13.17) with the difference of 9.10. In experimental group 2, 24 males (M=66.67, SD=17.67) mean performance in genetics shows that there it was lower the 25 females (M=71.60, SD=17.36) of the same group with the mean difference of 4.93. Overall across gender, the mean score performance of male pupils (M=62.18, SD=18.85) higher than female pupils (M=56.98, 20.71) with the difference of 5.2. And finally across group names, the mean performance scores show that the experimental group 1 (M=74.67, SD=12.59) performed better in genetics when ICT is used in the teaching and learning than when traditional method approach with control 1 (M=47.55, SD=17.79) with the mean difference of 27.21.

Table 4.12: Factorial analysis of variance Showing the genetics posttest performance as a function of gender and group names

variable and source	df	MS	F	p	ŋ2
Gender	1	1128.148	4.604	.033	.024
Group	3	8969.467	36.606	.000	.374
gender *group names	3	532.413	2.173	.093	.034
Error	184	245.030			

Table 4.12. shows that there was not a significant difference interaction between gender and group names on genetics performance when ICT tools are used in the teaching and learning of genetics, F (3, 184) =2.17, p= 0.93, $ŋ^2$ =0.034. So, it can be concluded that achievement post test scores were not impacted by any interaction of gender and group names.

However, there was a significant mean effect on gender and performance in genetics posttest scores when ICT tools are used in the teaching and learning of genetics, F (1, 184) =4.60, p= 0.033, $ŋ^2$ =0.024. The Eta for gender was 0.15, which is a large effect size according to Cohen (1988). Despite the significant differences in gender, the mean score of male learners was much greater than that of female learners. Thus, ICT integration approach in the teaching and learning of genetics was helpful for both male and female students.

Furthermore, there was a significant mean effect on group names on performance in genetics when ICT tools are used in the teaching and learning of genetics, F (2, 186) =0.29, p<0.001, $ŋ^2$ =0.37. The Eta for group names was 0.61, which is a large effect size, according to Cohen (1988).

Estimate marginal means of genetics performance of posttest a function of gender and group names

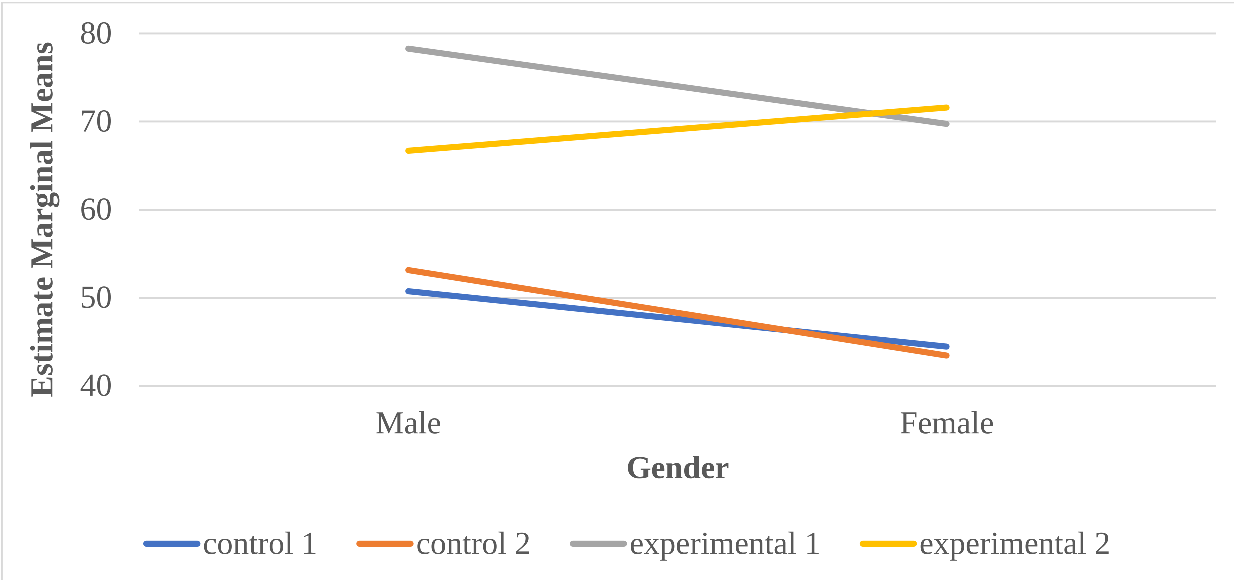


Figure 4.2. Profile plot of estimate marginal means of genetics performance of posttest a function of gender and group names

Figure 4.2. shows that females in experimental group 2 showed a significant increase in performance in genetics compared to males of the same group. Further, females in experimental group 2 also showed a significant increase in performance in for both males and female in control group 2. Male pupils in the experimental group 2 showed an increase in the performance than male pupils in the control group 2. However, males in the experimental group 1 showed a higher increase in performance than both males and females in control 1. Female pupils in experimental group performed lower than male pupils in experimental 1 and females in control 1 groups. The experimental 1 and experimental 2 performances in genetics using ICT tools are significantly different from control 1 and control 2 groups respectively.

4.2.4. Differences in genetics performance as a function of group name and age group

Table 4.13: Descriptive statistics mean comparisons for genetics post-test performance as a function of group name and age group

	<17 yrs			17≤19yrs			>19yrs			Total	
Group name	**n**	**M**	**SD**	**N**	**M**	**SD**	**n**	**M**	**SD**	**M**	**SD**
control 1	7	39.29	19.46	42	48.81	18.31	6	48.33	10.33	47.55	17.79
control 2	5	55.00	14.14	34	47.06	14.93	4	56.25	9.47	48.84	14.59
experimental 1	6	70.00	14.49	36	75.42	12.78	3	75.00	5.00	74.67	12.59
experimental 2	5	66.00	13.87	40	69.75	18.01	4	67.50	20.21	69.18	17.51
Total	23	56.52	19.68	152	60.23	20.39	17	59.41	15.50	59.71	19.87

In Table 4.13. The mean scores for 17≤ 19 yrs (M=75.42, SD=12.78) in experimental group 1 performed higher in genetics than those aged <17 yrs (M=70.00, SD=14.49) and >19 yrs (M=75.00, SD= 5.00) of the same group with the mean differences of 5.42 and 0.42 respectively. Further, the mean scores for 17≤ 19 yrs (M=75.42, SD=12.78) in experimental 1 performed higher in genetics among all age ranges in control groups 1; <17 yrs (M=39.29, SD=19.46), 17≤ 19 (48.81, SD=18.31) and >19 yrs (M=48.33, SD= 10.33) with mean differences of 36.13, 25.61 and 27.09 respectively. The mean performance score for 17≤ 19 yrs (M=69.75, SD=18.01) in genetics for experimental group 2 was also higher than those aged for <17 yrs (M=16.00, SD=13.87) and >19 yrs (M=67.50, SD= 20.21) of the same group with the mean differences of 0.75 and 0.2.25 respectively.

Finally, the mean scores for 17≤ 19 yrs (M=69.75, SD=18.01) in experimental 2 performed higher in genetics among all age ranges in control groups 2; <17 yrs (M=55.00, SD=14.14), 17≤ 19 (47.06, SD=114.93) and >19 yrs (M=56.25, SD= 9.47) with mean differences of 14.75, 22.68 and 13.50 respectively.

Overall across age range, the mean score performance of 17≤ 19 yrs (M=60.23, 20.39) higher than <17 yrs (M=56.52, SD=19.68) and >19 yrs (M=59.41, SD= 15.50) with the difference of 3.71 and 0.82. And finally across group names, the mean performance scores show that the experimental group 1 (M=74.67, SD=12.59) performed better in genetics when ICT is used in the teaching and learning than when traditional method approach with control 1 (M=47.55, SD=17.79) with the mean difference of 27.21. Experimental group 2 mean score (M= 69.18, SD=17.51) performance in genetics also higher than in control group 2 (M=48.84, SD=14.59) with the mean difference of 47.34.

Table 4.14: Factorial analysis of variance showing the genetics posttest performance as a function of Group names and age groups

variable and source	**df**	**MS**	**F**	**P**	**ŋ2**
Group names	3	3543.33	13.736	.000	.186
Age group	2	96.22	.373	.689	.004
Group names * Age group	6	168.77	.654	.687	.021
Error	180	257.95			

Table 4.14. shows that there was not a significant difference interaction between age and group names on genetics performance when ICT tools are used in the teaching and learning of genetics, F (6, 180) =0.65, p= 0.687, ŋ2 =0.021. So, it can be concluded that achievement post test scores in genetics were not impacted by any interaction of group names and age groups. However, there was a significant mean effect within group names performance in genetics posttest scores when ICT tools are used in the teaching and learning of genetics, F (3, 180) =13.74, p<0.001, ŋ2 =0.186. The Eta for gender was 0.43, which is a large effect size according to Cohen (1988). Thus, achievement post test scores in genetics were impacted by group names when ICT tools were used in the teaching and learning of genetics. Furthermore, there was no significant mean effect in age on performance in genetics when ICT tools are used in the teaching and learning of genetics, F (2, 180) =0.37, p<0.689, ŋ2 =0.004. The Eta for group names was 0.061, which is a small effect size, according to Cohen (1988). Then, it can be concluded that the performance of learners in group names did not dependent on their age groups. However, students of experimental groups performed better irrespective of their age group level.

Estimate marginal means of genetics performance of posttest a function of group name and age

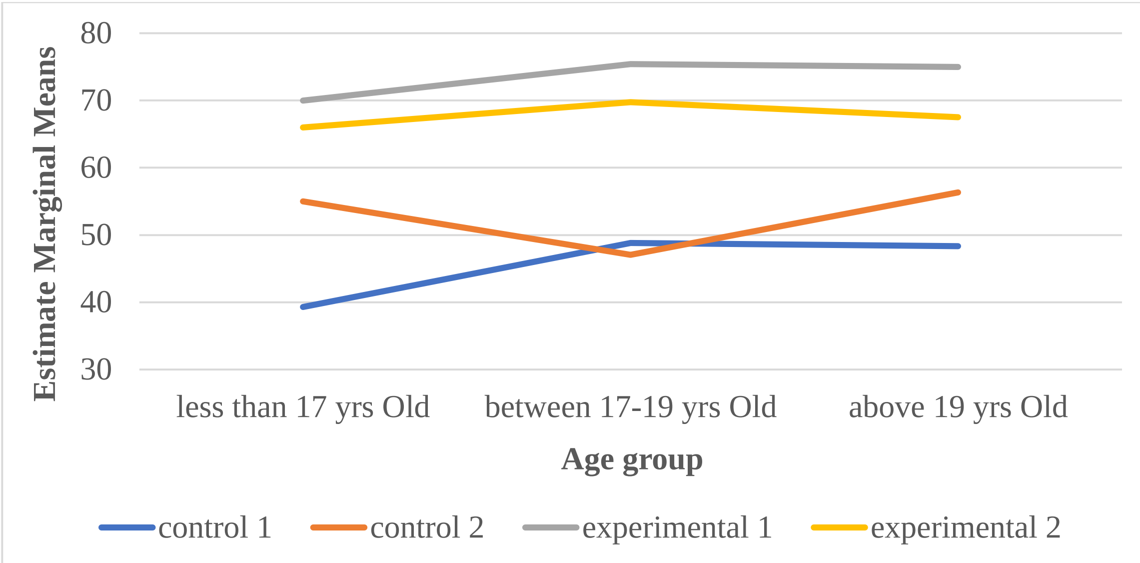


Figure 4.3: Profile plot of estimate marginal means of genetics performance of posttest a function of group name and age

Figure 4.3. shows that learners between 17-19 years old in experimental group 1 showed a significant increase in performance in genetics compared to the learners' in control group 1. Additionally, there was no significant interaction between pupils of the same age group in experimental group 1 and control group 1. However, learners' performance in genetics across all age groups in experimental 1 and experimental 2 showed that there was no significant interaction. In asmuchas the experimental 1 and experimental 2 showed no interaction across all age groups performed higher than learners in all control groups.

Further, learners' aged between 17-19 years old in experimental group 2 also showed a significant increase in performance as opposed to learners' of the same age in control group 2 who showed the decrease on genetics performance. There was not significant interaction between learners' performance in genetics in experimental 2 and control 2 groups. However, learners' aged less than 17 years old and above 19 years old in experimental 2 and control 2 groups, showed a slight significant interaction as the plots were slightly parallel to each other.

Finally, the experimental group 1 and experimental group 2 performances in genetics using ICT tools were significantly different across all age groups in control 1 and control 2 groups respectively. The learners' aged between 17-19 years old performed better in genetics that those of other groups in both experimental groups compared to all control groups.

4.3.1. Research question three

The study provided answers to the research question 3: What is the attitude of pupils on the use of ICTs in the teaching and learning of genetics?

4.3.2. Descriptive statistics and frequencies of pupils' attitudes towards the use of ICT tool in the teaching and learning of genetics

Table 4.15. shows that frequencies, average mean score and standard deviation for pupils' attitudes towards the use of ICT in the teaching and learning of genetics.

Table 4.15. Pupils' attitude on the use of ICT in the learning and teaching of genetics

SN	Item	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree	M	SD
		frequency (f) and percentage (%)							
1	A	16 (8.6%)	1 (0.5%)	4 (2.2%)	12 (6.5%)	33 (17.7%)	120 (64.5%)	5.18	1.48
2	B	17 (9.1%)	7 (3.8%)	8 (4.3%)	30 (16.1%)	49 (26.3%)	75 (40.3%)	4.68	1.56
3	C	17 (9.1%)	4 (2.2%)	16 (8.6%)	28 (15.1%)	42 (22.6%)	79 (42.5%)	4.67	1.58
4	D	16 (8.6%)	6 (3.2%)	10 (5.4%)	25 (13.4%)	51 (27.4%)	78 (41.9%)	4.74	1.54
5	E	13 (7.0%)	9 (4.8%)	19 (10.2%)	34 (18.3%)	54 (29.0%)	57 (30.6%)	4.49	1.49
6	F	32 (17.2%)	13 (7.0%)	14 (7.5%)	29 (15.6%)	42 (22.6%)	56 (30.1%)	4.1	1.83
7	G	12 (6.5%)	0 (0%)	15 (8.1%)	23 (12.4%)	34 (18.3%)	102 (54.8%)	5.01	1.43
8	H	13 (7.0%)	6 (3.2%)	10 (5.4%)	20 (10.8%)	49 (26.3%)	88 (47.3%)	4.88	1.48
9	I	17 (9.1%)	7 (3.8%)	10 (5.4%)	33 (17.7%)	50 (26.9%)	69 (37.1%)	4.61	1.56
10	J	16 (8.6%)	11 (5.9%)	11 (5.9%)	26 (14.0%)	44 (23.7%)	78 (41.9%)	4.64	1.61
11	K	21 (11.3%)	9 (4.8%)	8 (4.3%)	23 (12.4%)	45 (24.2%)	80 (43.0%)	4.62	1.69
12	L	16 (8.6%)	9 (4.8%)	7 (3.8%)	24 (12.9%)	36 (19.4%)	94 (50.5%)	4.81	1.61
13	M	18 (9.7%)	7 (3.8%)	11 (5.9%)	37 (19.9%)	32 (17.2%)	81 (43.5%)	4.62	1.62
14	N	8 (4.3%)	7 (3.8%)	8 (4.3%)	23 (12.4%)	41 (22.0%)	99 (53.2%)	5.04	1.37

Items

- *A.* *The use of ICT tools was an interesting experience.*
- *B.* *In understanding the concepts of genetics, the use of ICT tools is better than the traditional classroom presentation.*
- *C.* *Use of ICT tools allows one to discuss genetics with others much more that the traditional approach method.*
- *D.* *My level of motivation on genetics has increased with the use of ICT tools.*
- *E.* *The information on all the lessons on ICT tools was clear.*
- *F.* *The amount and quality of material in the use of ICT tools were just about the right compared to what would normally be covered in a normal traditional classroom.*
- *G.* *The use of ICT tools has increased my degree of interest in genetics and biology.*
- *H.* *The ICT tools allowed me to understand complicated concepts in genetics better.*
- *I.* *The use of ICT offered me an ideal environment for learning and sequencing various ideas on each lesson than traditional methods.*
- *J.* *The use of ICT in genetics made me more creative.*
- *K.* *I have learnt more things about genetics through the use of ICT than I learned using Traditional methods.*
- *L.* *I would like that genetics be taught with the use of ICT tool than using Traditional methods only.*
- *M.* *I would like the Traditional method of learning genetics be replaced completed with the use ICT tools in the teaching and learning rather than only supplementing it.*
- *N.* *I recommend the use of the ICT tools in the learning of genetics and other topics in Biology.*

From the data provided in Table 4.15, the results showed that most pupils appreciated the use of ICT tools as an interesting experience and further agreed that ICT tools increased their degree of interest in genetics teaching and learning process as shown by means score 5.18 and 5.01 respectively. It is undeniable that interest in the learning any subject is cardinal as it helps learners to build confidence in themselves, their studies and may improve research and innovation.

Besides, most learners agreed that the use of ICT tools in the teaching and learning of genetics increased their levels of motivation with the mean score of 4.74. An increase in motivation essentially boost self-esteem and optimism. This quality is essential in keeping the learners constantly engaged in different aspect during the teaching and learning process. This situation shows that learners use of ICT tools in teaching and learning process as something positive where ICT is the aid needed by teachers to ensure the effectiveness of both teaching and learning process. Table 4.15 also shows that the use of ICT tools in teaching and learning of genetics enable the learners to be more active and engaging in discussions with others more than in the traditional approach learning environment with the mean score of 4.67. This is because learners are familiar with ICT and they find it easier learning by ICT and enabled them to be engage more in the lesson.

Furthermore, the results show that pupils found that ICT tools allowed them to understand complicated concepts in genetics and that information is clear when ICT tools are used in the teaching and learning processes as showed by the means scores of 4.88 and 4.49 respectively. ICT tools provide dynamic means that can be used to present similar information in difference way so as to reinforce comprehension in the teaching and learning of genetics, thus learners are able to learn and view a concept in genetics in different modes.

Other than that, learners recommended the use of ICT tools in the teaching and learning of genetics and other topics in biology with the mean score of 5.04, and established that in understanding the concepts of genetics, the use of ICT tools is better than the traditional approach with the mean score of 4.68.

4.3.4. Pupils attitude mean score on the use of ICT tool in the teaching and learning of genetics

Figure 4.4 below showed that the attitude mean score highest frequency values were 11 (5.9%) that ranged between slightly agree and moderately agree, and followed by 10 (5.4%) that ranged between moderately agree to strongly agree. The attitude mean score showed 4.72 (SD= 0.93). The results of the study implied that pupils were willing to embrace ICTs in the teaching and learning of genetics.

Pupils' attitude mean score of means and standard deviation

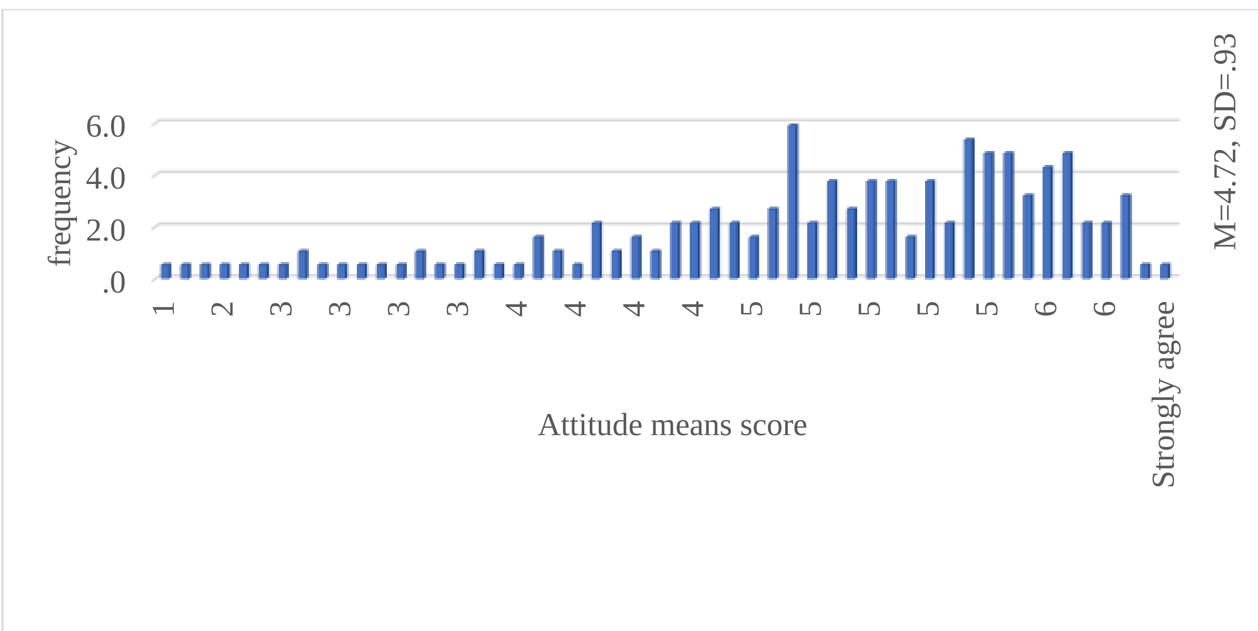


Figure 4.4. Pupils' attitude mean score of means and standard deviation

4.3.5. Inferential analysis of pupils means attitude questionnaires using one-way ANOVA

Table 4.16: Mean and standard deviation comparisons of pupils mean attitude scores

Group names	N	M	SD
control 1	51	3.98	1.163
control 2	41	4.58	0.605
experimental 1	50	5.22	0.556
experimental 2	44	5.14	0.532
Total	186	4.72	0.926

Table 4.17: One-way ANOVA showing pupils mean attitude scores across all groups.

	SS	df	MS	F	p
Between Groups	48.93	3	16.31	27.09	.000
Within Groups	109.58	182	.60		
Total	158.51	185			

Table 4.16 indicated that there was an increase in pupils mean attitude scores for experimental 1 and 2 (M= 5.22 and 5.14) respectively with the highest pupil attitude mean score shown in the experimental group 1. While the control groups 1 and 2 showed the significantly lower means (M= 3.98 and 4.58) with the lowest pupil attitude mean score shown in control group 1.

Table 4.17 indicate that the ICT tools that were integrated in the teaching and learning of genetics had a significant impact on learner's attitudes in genetics $F (3, 182) =27.09$, $p<0.001$, $\eta^2 =0.309$. Thus, the second null hypothesis was rejected (H_{02}) and the alternative (H_{1A}) was accepted. There is a significant difference in pupils' attitudes when ICT is used in the teaching and learning of genetics. This implies that the attitude of pupils towards use ICT in the teaching and learning of genetics differed for different groups (control 1 and 2 groups, and experimental 1 and 2 groups).

Table 4.18: shows the Post Hoc homogenous subset of pupils' attitude mean scores in all group names

		Subset for alpha = 0.05		
Group name	**N**	**1**	**2**	**3**
control 1	51	3.98		
control 2	41		4.58	
experimental 2	44			5.14
experimental 1	50			5.22
Sig.		1.000	1.000	.966

The assumptions of the homogenous subset states that:

1. Groups that share the same column are not significantly different
2. Groups that do not share the same column are significantly different

Table 4.18 shows that there was no significant difference between experimental 1 and 2 groups because they all shared the same column or subset 3. However, was a significant difference among all three subsets: the experimental 1 and 2, control 2 and 1 groups (M=5.22 and 5.14, M=4.58 and 3.98) respectively. Further, the experimental 1 and 2 groups were significantly higher that the control 2 and 1 groups. Therefore, learners' showed the highest (positive) mean score attitude towards the integration of ICT tools in the teaching and learning.

Table 4.19: shows the Post Hoc multiple comparison of pupils' attitude mean scores in all group names

Group name		**MD (I-J)**	**p**
control 1	control 2	-.595*	0.002
	experimental 1	-1.237*	0
	experimental 2	-1.161*	0
control 2	control 1	.595*	0.002
	experimental 1	-.642*	0.001
	experimental 2	-.566*	0.005
experimental 1	control 1	1.237*	0
	control 2	.642*	0.001
	experimental 2	0.076	0.965

Table 4.19 shows the post hoc comparison using Tukey HSD test indicate that there was a significant difference in the mean attitude scores between control 1 (M=3.98, SD= 1.16) and control 2 (M=4.58, SD=0.60) with the p=0.002 and d=0.65. Therefore, there was a medium effect size as d=.0.65 is between 0.5 and 0.8 (Cohen, 1988). There was a significant difference in the mean attitude scores between control 1 (M=3.98, SD= 1.16) and experimental 1 (M=5.22, SD=0.56) with the p<0.001 and d=1.36. Therefore, there was a large effect size as d=1.36 is greater than d=0.8 (Cohen, 1988). There was a significant difference in the mean attitude scores between control 1 (M=3.98, SD= 1.16) and experimental 2 (M=5.14, SD=0.53) with the p<0.001 and d=1.28. Therefore, there was a large effect size as d=1.28 is greater than d=0.8 (Cohen, 1988). There was a significant difference in the mean attitude scores between control 2 (M=4.58, SD=0.60) and experimental 1 (M=5.22, SD=0.56) with the p=0.002 and d=1.13. Therefore, there was a large effect size as d=1.13 is greater than d=0.8 (Cohen, 1988). There was a significant difference in the mean attitude scores between control 2 (M=4.58, SD=0.60) and experimental 2 (M=5.14, SD=0.53) with the p=0.005 and d=0.98. Therefore, there was a large effect size as d=0.98 is greater than d=0.8 (Cohen, 1988). However, there was no significant difference between experimental group 1 and experimental 2 (p=0.97).

4.3.6. Qualitative data analysis of pupils' attitude on the use of ICT tools in the teaching and learning of genetics

Thematic analysis was used to analyse qualitative data. Themes were generated from the emerging common factors and sub-headings were formed.

4.3.6a. Pupils' attitudes on the use of ICT tool in the teaching and learning of genetics

The study provided answers to the research question 3: What is the attitude of pupils on the use of ICT in the teaching and learning of genetics?

Pupils knowledge of ICT tools

Pupils showed an intense amount of knowledge on ICT tools and how they can be used in the teaching and learning process. Some of the mentioned ICT tools include the following: computers, laptops, iPads, projectors, videos, audios, phones, e-Tablets, and computer and phone softwares or applications (such as WhatsApp messenger, Facebook messenger, Microsoft office) and some websites (Wikipedia, google scholar). One interviewee stated:

> *"WhatsApp, Imo and Viber messengers can be used for discussions, submission of homeworks and delivering lessons to pupils during*

*weekends so that we are kept active during the week. These instant messengers can also act as medium through which we can be relaying information (problems) to teachers that we are finding hard to understand especially after classroom hours." **(excerpt 1)***

Pupils emphasised that ICT tools could increase their attitude positively towards genetics if teachers used other alternatives forms of teaching and learning approaches in genetics. They further added that their knowledge of ICT if used well by teachers through corroborative teaching can be useful in their learning of genetics. One interviewee stated;

*"We have skills because we were born in the technological age, were we have been using video games, computer games, online games and much of our time is spent on surfing the internet. So we do not think that it can be difficult for us to embrace ICTs in classroom settings. Teachers need to engage us in the modern age of technology and the purported difficult genetics will be a walk-over and history in our learning." **(excerpt 2)***

Pupils access to ICT infrastructure in schools

Poor access to ICT infrastructure by pupils in school has had a negative effect on learners' confidence in the use of ICT tools in school, .and consequently, the depths of knowledge and research skill that pupils have on ICT tools. Only those classes that study computers science have access to computers laboratories and ICT tools such as printers and computers. One interviewee stated:

*ICT infrastructure in schools are poorly equipped that its hardly possible to install latest computing technologies (softwares) on them. Most of the computers in schools have old version programmes that cannot accommodate new and upgraded computer softwares. This also has contributed to learners not engaging themselves in the learning of genetics and any other biology topics using ICT tools. I remember one teacher wanted us to research on some projects for JETTS, but computers just failed to connect to the routers he provided. So we relied on the teachers' laptop. **(excerpt 3)***

Thus, there was no variation in which information was being presented in the teaching and learning of genetics or any other topic in biology due to poor ICT infrastructures in schools. One interviewee stated that:

> *"Learning become boring especially when you know that genetics is very difficult and the teaching approaching is the same. You get demoralised before you even start learning genetics, but if schools can provide quality teaching and learning environment such as biology computer laboratories, lessons on genetics can be very interesting. Then, research on genetics and learning through backup and installed data base genetics programmes can inspire the positive attitude of learners on genetics, but the ICT infrastructure is very poor and demotivating"* ***(excerpt 4)***

ICT infrastructures in schools demotivates learners to do research and solve genetics problems as effective as they could handle most problems if ICT infrastructure was well equipped with proper ICT tools.

Another interviewee stated that;

> *"There is no Wi-Fi in school which also contributed to poor research by us learners in genetics. Additionally, school do not allow access to come with our own electronic gadgets except those who are studying computers science, but again it is only on time-tabled days that those learners allowed to come with the electronic gadgets."* ***(excerpt 5)***

They purported that there was a relationship between ICT infrastructures and the attitude of learners towards genetics and other subjects in school.

Another interviewee stated that;

> *"ICTs can offer a lot of materials for research, from videos, audios, softcopies materials, live chats and other blogs where we can be consulting from daily. But our school systems cannot allow us to have access to all these privileges because of poor ICT facilities. If only we had these services at our disposal, genetics would be made simple because we can have anything*

we would need at a lick of a button such as Simulations and videos on genetics." ***(excerpt 6)***

Pedagogical use of ICT tools

Pupils did not learn any topic in biology (genetics) using ICT tools. They felt that teachers did not have enough knowledge of how to integrate ICT tools in the teaching and learning of genetics.

One interviewee contended that:

> *"No teacher in any subject has used any ICTs in the teaching and learning process, not even when teaching genetics. I strongly feel these our teachers do not know how to use ICT tool. It is shocking that they have laptops but they cannot use them to prepare and teach lessons using even a simple projector to show illustrations. We all know that genetics is too abstracts to be taught with a chalk and a board. It needs somethings like ICTs to bring out the reality content of it."* ***(excerpt 7)***

Another interviewee indicated that:

> *"This why we fail and think that genetics is very hard because our teachers are not innovative in nature. They know that we learners have challenges in understanding genetics, but nothing changes in the way they present information to us on genetics. It is just talking and giving us notes capwa (only), no ICTs."* ***(excerpt 8)***

However, pupils believed that the use of ICT tools in the teaching and learning process can be used to improving the delivery of the abstractness content of genetics. One interviewee said that:

> *"If ICT tools are used well in the teaching and learning of genetics, it can provide multimodal way of learning to us learners'. The fear of failure of learning genetics can even finish since its concepts can be made easy to learn and understand."* ***(excerpt 8)***

Therefore, learners held that the use of ICT tools improve the pedagogical approaches and conversely positively improve the attitudes of learners' in the learning of genetics. Learners also held that pedagogical approaches in genetics be integrated with ICTs in the teaching and learning of genetics.

Significance of ICT tools

Learners believed that ICT tools are important aspects in the teaching and learning of genetics.

One interviewee stated that:

> *"It was difficult to forget a concepts learnt from ICT tools because lessons on genetics were taught in different learning modalities (audio, video, practical etc.). The interviewee, further, cited that problems that involved the use of graphs could easily be taught or tackled using ICT tools such as Microsoft packages. And those that involved the study of DNA replication could be taught using video simulations. Use of ICTs helps to main high retention power and helps in academic prowess." **(excerpt 9)***

Another interviewee stated that:

> *"I strongly believe that the lessons that are ICT based are more creative, interactive, engaging, and inspire us learners to learn new things every day through exposure to different ICT tools. Further, ICT tools can positively improve the learners' self-concept of genetics as a topic and further developed as positive attitudes towards genetics." **(excerpt 10)***

another interviewee stated that:

> *"ICT tools such as computer based media interaction (Gene-X simulation software) can build the confident in research and problem solving skills in genetics for us learners'. Softwares are able to provide immediate feedback to some series of problems that learners' attempts immediately the tasks are done by a learner." **(excerpt 11)***

Use of aids and resources broadens

The integration of ICT tool in the teaching and learning of genetics broadens the array of resources to using in the teaching and learning processes. Most learners' indicated that ICT tools have the potential to provide different types of resources for preparation and delivery of content to the learners within and outside the lessons. One interviewee stated that;

> *"they are a lot of things online that we as pupils have not even explored when we are learning genetics or any subject. The internet for example has all the facilities we can need for effective study and grasping the concepts in ranging from genetics simulation laboratories, e-text books, online consultation blogs and past papers."* ***(excerpt 12)***

Learners felt that ICT tools use in genetics can foster their comprehension of subtopics of genetics better if it can be used as a resource tool in the teaching and learning process.

Another interviewee stated that:

> *"Genetics as a topic has a lot of subtopics, each with a different view point of focus (gene interaction, variations, heredity, DNA replication and mutations) and in order to understand these abstract subtopics better, I believe that ICTs can provide one of the best resources to explaining these concepts."* ***(excerpt 13)***

ICT tools can bring realism into learning

learners believed that it can bring realism in the teaching and learning of genetics, because of the different resources that ICT tools are able to offer. One interviewee stated that:

> *"It is not enough to just rely on our super imagination every time we are learning genetics. Some things can be imagined and visualised well, but not the contents of genetics. As such, ICT tools can be used to give picture and visualise concepts using different forms of ICT tools, for example, a normal cell can be seen deforming in to a sickle cell during the process of mutation through DNA simulations, and mutations can be demonstrated*

on the computers using computers softwares with safety and zero contamination levels" ***(excerpt 14)***

Another interviewee added that;

> *"…the use of ICT tools can link the imaginary unformed picture to the reality of what obtains in genetics at the genetic level (genes, cell division, DNA), unlike just conceptualising the processes of genetics with the mind."* ***(excerpt 15)***

Another interviewee attested that:

> *"…the use of ICT tools bring content to life, and it is really hard to forget the experience of reality outside the book. It helps us to put genetics into context and experiencing it as a reality topic not as an abstract difficult topic to learn."* ***(excerpt 16)***

In addition, ICT tools can help to create a less intimidating environment for learning genetics for weaker learners.

One interviewee stated that:

> *"I know I am not good with imaginations, visualisation and contextualising text information. For me, as a learner, I learn and understand better concepts or things that I am able to see. It is less intimidating for me then to learn genetics with ICT tools because I am made to see almost everything that is happening. I don't need to start figuring out how the sickle cell looks like or how it is form when I can easily see the process through simulations."* ***(excerpt 17)***

Learners should a positive attitude toward the use of ICTs in the teaching and learning of genetics. They believed that ICTs can make genetics more manageable to learn through the resources it provides.

4.4.1. Research question four

The study provided answers to the research question 4: What is the attitude of teachers on the use of ICT in the teaching and learning of genetics?

4.4.2. Overview

To ascertain the attitude of teachers on the use of ICTs in the teaching and learning of genetics, 6-Likert type set of questions were asked requiring the respondents to indicate their levels of agreement with the statements. Descriptive statistics (frequency table) and Mann-Whitney U test was used to analyse the attitudes of teachers on the use of ICT in the teaching and learning of genetics. Teachers' attitude questionnaires were transformed from ordinal data into mean attitude score (scale data) using SPSS for the purpose of analysing data using quantitatively (Morgan e'tal, 2011: 83). Furthermore, qualitative data was collected using focused group discussions in all four group names, and data was analysed thematically.

4.4.3. Descriptive statistics and frequencies of teachers' attitudes towards the use of ICT tool in the teaching and learning of genetics

Table 4.20. shows that frequencies, average mean scores and standard deviations for teachers' attitudes towards the use of ICT in the teaching and learning of genetics.

Table 4.20. Teachers' attitude on the use of ICT in the learning and teaching of genetics

SN	Item	Strongly disagree	Moderately disagree	Slightly disagree	Slightly agree	Moderately agree	Strongly agree	M	SD
		frequency (f) and percentage (%)							
1	A	0	0	0	0	1 (10%)	1 (90%)	5.90	.32
2	B	0	0	0	0	3 (30%)	7 (70.%)	5.70	.48
3	C	0	0	0	1 (10%)	3(30%)	6 (60%)	5.50	.70
4	D	0	0	0	0	2 (20%)	8 (80%)	5.80	.42
5	E	0	0	1(10%)	0	2 (20.0%)	7 (70%)	5.50	.97
6	F	0	0	0	0	2 (20%)	8 (80%)	5.80	.42
7	G	0	0	0	0	5 (50%)	5 (50%)	5.50	.53
8	H	0	0	0	2 (20%)	3 (30%)	5 (50%)	5.30	.82

9	I	0	0	0	0	5 (50%)	5 (50%)	5.50	.53
10	J	0	0	1 (10%)	3 (30%)	3 (30%)	3 (30%)	4.80	1.03
11	K	0	0	0	0	5 (50%)	5 (50%)	5.50	.53
12	L	1 (10%)	1 (10%)	1 (10%)	0	3 (30%)	4 (40%)	4.50	1.84
13	M	2 (20%)	0	1(10%)	3 (30%)	3 (30%)	1 (10%)	3.80	1.68
14	N	0	0	0	1 (10%)	7 (70%)	2 (20%)	5.10	.57

Items

A. *I believe the use of ICT tools in teaching is an interesting experience*
B. *I understand the abstract concepts of genetics can be explained and understood better by the use of ICT tools in teaching than the traditional classroom presentation*
C. *Use of ICT tools allows one to discuss genetics with others much more than the traditional approach method*
D. *The use of ICT tools in teaching can increase the levels of motivation in genetics*
E. *The information on all the lessons on genetics can be made more clear through the use of ICT tools.*
F. *The use of ICT tools in teaching can add quality to the materials for genetics compared to what would normally be covered in a normal traditional classroom.*
G. *The use of ICT tools in teaching can increased my degree of interest in genetics and biology.*
H. *The ICT tools allowed me to understand complicated concepts in genetics better*
I. *The use of ICT offers me an ideal environment for learning and sequencing various ideas on each genetics subtopic than traditional methods.*
J. *The use of ICT in genetics can provide for more creativity in planning and teaching of genetics.*
K. *I can teach more things about genetics through the use of ICT than I teach using Traditional methods.*
L. *I would like that genetics be taught with the use of ICT tool than using Traditional methods only.*
M. *I would like the Traditional method of teaching genetics be replaced completely with the use ICT tools in the teaching and learning rather than only supplementing it.*
N. *I recommend the use of the ICT tools in the teaching of genetics and other topics in Biology.*

Table 4.20 showed that 9 (90.0%) strongly agreed, 1 (10.0 %) with item 1. This showed that teachers believed that the use of ICT tools in teaching is an interesting experience with the highest strongly agreeing percentage ranking of 90% (M=5.90, SD=0.32).

Table 4.20, showed that teachers strongly agreed 7 (70.0%) that they understood and explained better the abstract concepts of genetics by the use of ICT tools in the teaching process than the traditional classroom presentation with the mean score 5.70 (SD=0.48). Additionally, teachers strongly agreed 6 (60.0%)that the use of ICT tools allowed learners and teachers to discuss genetics with others much more than the traditional approach method with the mean score of 5.50 (SD=0.70). Furthermore, the study revealed that **7 (**70.0%) of teachers strongly agreed that the information on all the lessons on genetics can be made more clear through the use of ICT tools much more than the traditional approach method with the mean score of 5.50 (SD=0.97).

Table 4.20 also showed that 8 (80.0%) teachers strongly agreed that the use of ICT tools in teaching added quality to the materials for genetics compared to what would normally be covered in a normal traditional classroom with the mean score 5.80 (SD=0.42).

Additionally, results of the study also showed that teachers strongly agreed 8 (80.0%) that their levels of motivation increased when teaching genetics using ICT tools with the mean score of M=5.80, SD=0.42).

Table 4.20 showed that the use of ICT tools in teaching increased teachers' degree of interest in genetics and biology with equal agreement in both strongly and moderately agreeing percentage ranking of 50.0% and the mean score of 5.50 (SD=0.53).

Table 4.20 showed that 5 (50.0%) strongly agreed that the use of ICT tools allowed teachers to understand complicated concepts in genetics better with the mean score of 5.30 (SD=0.82). Further, the results showed that the use of ICT tool in the teaching of genetics provided for more creativity in planning and teaching of genetics which was more inclined on the agreement (30.0%) and the mean score of 4.80 (SD=1.03).

Table 4.20. showed that 5 (50.0%) of 5 (50.0 %) of teachers strongly agreed and moderately agreed that teachers taught more things about genetics through the use of ICT than when teaching using Traditional methods with the mean score of 5.50 (SD=0.53). Additionally, the results showed that 4 (40.0%) teachers strongly agreed they would like that genetics be taught with the use of ICT tools than using traditional methods only with the mean score of 4.50 (SD=1.84).

In addition, the results revealed teachers would like that traditional method of learning genetics be replaced completely with the use ICT tools in the teaching and learning rather than only supplementing it with the moderately and slightly agreeing percentage rankings of 30% and with the mean score of 3.80 (SD=1.68). However, teachers' attitudes towards completely replacing ICT tools in the teaching and learning of genetics showed the low mean score of 3.80.

Finally, results revealed that 7 (70.0 %) teachers moderately agreed and recommended the use of the ICT tools in the teaching of genetics and other topics in Biology with the mean score of 5.10 (SD=0.57).

4.4.4. Teachers attitude means scores towards the use of ICT in teaching and learning genetics

Frequency, means and standard deviation of teachers' attitude mean scores

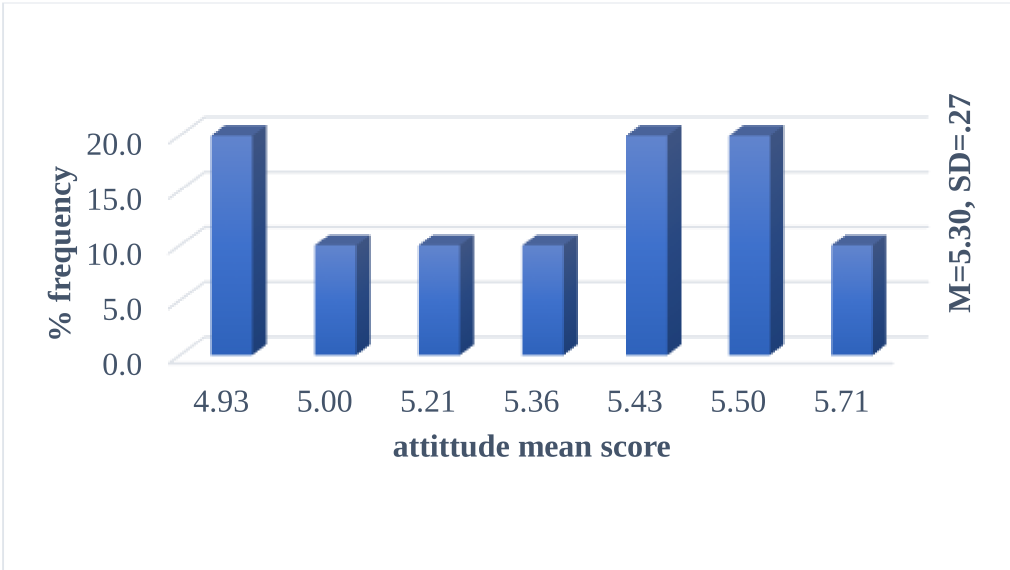


Figure 4.5: Frequency, means and standard deviation of teachers' attitude mean scores

Figure 4.5. showed that teachers had a positive attitude towards the use of ICT tools in the teaching and learning of genetics with the attitude mean score of 5.30 (SD=.27). The results implied that teachers were agreeable to use ICTs in the teaching and learning of genetics.

4.4.5. Difference in teachers' attitude of integrating ICT tools between gender

Mann-Whitney U tests were conducted to compare the differences in the attitude of teachers towards the use of ICT tools in the teaching and learning of genetics between gender. Table 4.21. show the descriptive means ranks differences of teachers' attitudes. While Table 4.22 shows the Mann-Whitney test showing the statistical test difference of teachers' attitude on the use of ICTs in the teaching and learning of genetics against gender.

Table 4.21: Mean ranks differences of teachers' attitudes

	Gender	N	MK	SR
teachers mean attitude score	male	4	4.25	17.00
	female	5	5.60	28.00
	Total	9		

Table 4.22: Mean scores differences of teachers' attitude on ICT use against gender

	mean attitude scores
Mann-Whitney U	7.000
Wilcoxon W	17.000
Z	-.741
Asymp. Sig. (2-tailed)	.459
Exact Sig. [2*(1-tailed Sig.)]	.556[b]

Tables 4.21 and 4.22 shows that the 5 female teachers did not have a significantly higher mean ranks (M=5.60) than the 4 male teachers (M=4.25) on the teachers' attitude towards integration of ICT tools in the teaching and learning of genetics, U=7.00, p=0.66, r=-0.23, which according to Cohen (1988), is a small to medium effect size. The third null hypothesis was rejected and the alternative hypothesis was accepted that there is a significant difference in teachers' attitudes when ICT is used in the teaching and learning of genetics.

4.4.5. Qualitative data analysis of teachers' attitude on the use of ICT tools in the teaching and learning of genetics

Thematic analysis was used to analyse qualitative data. Themes were generated from the emerging common factor and sub-headings were formed.

4.4.6. Teachers attitudes on the use of ICT tool in the teaching and learning

Teachers' knowledge of ICT tools in the teaching and learning of genetics

Most teacher were found to have little or no knowledge of ICT tools that could be used in the teaching and learning of genetics. Furthermore, teachers exhibited poor knowledge on different types of ICT tools that could be used in the teaching and learning of genetics. However, teachers were able to cite some of the ICT tools that they were familiar with: general computers, laptops, projectors, scanners and photocopiers. Nevertheless, most of teachers did not have enough knowledge on how to integrate ICT tools in the teaching and learning of genetics apart from some basic knowledge on Microsoft word which they used for typing lesson plans and schemes of work. One interviewee responded that,

> *"...most of us teachers have little, if not, no knowledge on the use ICT tools in the teaching and learning processes apart from social media interactions (using Facebook, WhatsApp, Imo), typing lesson plans,*

minutes of the meetings, printing, playing music, storing information (mostly non-academic) and watching movies online (non-academic) from the computers or laptops" ***(excerpt 1)***

Another interviewee stated that:

"it is difficult to identify which ICT tools can be used in the teaching and learning of genetics if you do not have enough knowledge about the subject, this make it hard to use ICT tools in teaching and learning processes." ***(excerpt 2)***

Thus, teachers' knowledge on the use ICT tools have contributed to poor teaching and learning practices, performance and the negative attitude towards genetics by most teachers of biology. Because there was difference on how much teachers knew about ICT tools, it caused them to have a lower negative attitude towards the use and implementation of ICT tools in the teaching and learning of genetics.

Teachers skills on the use of ICT tools in the teaching and learning of genetics

Teachers' competence on the use of ICT tools in the teaching and learning of genetics was very limited to typing, printing and storing of information on biology. It was found that teachers have not explored the uses of ICT tools such as Microsoft excel, Microsoft PowerPoint, videos or other computer based softwares and programs in the teaching and learning of genetics because of their incompetent skills in the use of ICT tools in the teaching and learning of genetics. One interviewee added that,

"it is difficult to even think that Microsoft word or excel can be used to interpret and analysis data in genetics, and later alone possess the skills to integrate these tools in the teaching and learning of genetics." ***(excerpt 3)***

Another interviewee added that;

"I have never had the opportunity to explore the ICT tools that can be used in the teaching and learning of genetics. I simply do not have the skills on how to use these ICTs in the teaching and learning processes. Even if I was given the ICT tools today, I would use them." ***(excerpt 4)***

The majority of the teachers that were interviewed were found to have no skills in ICT tools usage and application in the teaching and learning of genetics. One teacher stated that:

> *"The main skills most of us have is printing and typing. Most of us cannot connect a projector to the laptop and use it in the teaching and learning of genetics or any other topics in biology. I believe it is difficulty to use the ICT tools in the teaching and learning of genetics with our skills."* ***(excerpt 5)***

Thus, most teachers believed that ICT tools were hard to understand and learn, making it even impossible to use them in the teaching and learning of genetics.

Lack of biology ICT training in education institutions

Apart from those teachers that were trained in fast-track when there was an introduction to ICT in school. There are no teachers that have been trained in the use of ICT tools in the teaching and learning of biology (genetics). This has contributed to poor innovative methods of teaching and learning genetics by teachers of biology. Subsequently, the poor attitude that genetics is held by most teachers as a difficult topic to teach. Another interviewee added,

> *"education institutions have no curriculum on the integration of ICT tools in the teaching and learning of biology (genetics). This make us fail to use these ICT tools in the teaching and learning of biology and specifically genetics. Even when we try to use ICTs, we fail because of lack of training. We lack the know how in ICT tools"* ***(excerpt 6)***

Teachers insisted that education institutions be established or courses in biology at higher institution of learning that have ICT integrated in biology (genetics).

Another interviewee added:

> *"educational institutions should formulate ICT programmes in biology with well-directed and specific ICT tools that can be used in the teaching and learning of genetics."* ***(excerpt 7)***

This they believed would stimulate the teacher to have a positive attitude towards ICT integration in genetics or biology.

No Continuous professional development (CPD) in ICT tool in genetics

There are no CPD programmes that involve the use of ICT tools in the teaching and learning of genetics or biology in biology departments, schools, districts or provincial levels. This has shown that there is no integration of ICT tools in the teaching and learning of genetics. One interviewee attested that;

> *"we have never had a CPD on how well genetics can be taught using computer based tools either at school, district level or provincial level."* ***(excerpt 8)***

Teachers had a view that the difficulty of ICT based teaching and learning can only be achieved through CPD programmes at all levels in the education sector.

> *"Specialists in ICT would have to be invited in schools, districts or provincial levels to train teachers with some based on useful ICT tools, and help them to select manageable ICT tools that can be used by biology educationist in the teaching and learning of genetics."* ***(excerpt 9)***

Otherwise, ICT integration on the teaching and learning of biology can be difficulty to implement in schools.

Management in teaching and learning of genetics

Most teachers thought that the use of ICT tools could be used to manage classroom lessons well through preparation of lesson plans, explaining abstract concepts and solve problems of genetics better. One interviewee held that,

> *"genetics is too abstract and difficult to teach and understand, so if ICT tools can be used in the teaching and learning processes, difficult concepts can easily be showed and explained to learners with ease."* ***(excerpt 10)***

They also believe that the use of ICT tools demands an extra effort and creativity as a teacher. Thus, this can give teachers the impetus to be focused when delivering the content and practicals in genetics during the teaching and learning of genetics. One interviewee held that,

> *"ICTs demand extra effort and creativity and as such, delivery of content, problem solving skills and practicals can easily be handled by the teachers in the teaching and learning of genetics."* ***(excerpt 11)***

Therefore, time is managed well and time is not lost in trying to explain abstract concepts in genetic e.g. a simulated video of mutation can be play to explain mutations in cells, both chromosomal and point mutation with effortlessly. Another interviewee added that:

> *"If used well in the classrooms through careful planning, ICT tools can be time and cost effective in the delivery of lessons. There is no need to struggle to draw biological biology or carry out dangerous experiments, when every can be accessed on other ICT tool packages that may contain more than four or five different programmes on genetics."* ***(excerpt 12)***

ICT tools as motivational media to learners

ICT tools can also act as a motivational media to learners' in the teaching and learning of genetics. Most learners have smart phone or laptops where they come from and failing to meet the daily learners needed especially in this 21st century creates a barrier in the teaching and learning process. So introducing something that pupils already own and do at their homes, and in their lives can give them the motivation even to concentrate and participate fully during the process of teaching and learning of genetics. One interviewee added that:

> *"our learners have smart phone, laptops, and computers and they even know how to do run these ICT tools better than us because they explore them more than us teachers. So engaging them in the teaching and learning of genetics with the things they are familiar with can grasp their attention and improve their motivation in learning the topic they fear more."* ***(excerpt 13)***

Further, the presentation of information on different multimodal media can also help learners to understand and solve problematic concepts in genetics as different learners do not learn using a single method of teaching. Another interviewee added that:

> *"ICT tools have the potential to display and give learners the same information in more than two ways. This can act as a catalyst to stimulate learners and better their performance and attitude in genetics."* ***(excerpt 14)***

Most teachers were convinced that ICT tools can be great tools that can push learners a mile stone in appreciating and enjoying genetics in the teaching and learning process by acting as motivational factors (intrinsic and extrinsic factors). Furthermore, pupils' knowledge can be redirected in creating platforms were they are able to solve their own problems in genetics even after school hours.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1. Overview

In this chapter, the researcher discusses the findings from chapter four by giving reference to the existing knowledge through the literature presented in chapter two, research objectives, and theoretical framework. Finally, the findings were discussed according to the research objectives.

5.1.1. ICT tools (Excel, videos, simulations) enhance pupils' performance in Genetics

The study pursued to established if ICT tools (Excel, videos, simulations) enhance pupils' performance in genetics at two elected schools in Kitwe district when it is used as an enhancement to traditional teaching learning methods.

5.1.2. Performance of pupils who were exposed to ICT tools as enhancement to traditional teaching and learning approach

The study revealed that ICT tools when used as enhancement tools to traditional teaching and learning approach enhances pupil's performance in genetics. As a result, there was a significant difference in pupils' performance when ICTs were used as enhancement tools to traditional teaching and learning of genetics. This implied that genetics scores or performance of pupils in genetics differed for different groups, that is, pupils in the experimental groups performed better than pupils in the control groups.

The results collaborated with Kaulu (2008) findings which revealed that the use of computer based instructions enhance performance when used as a supplement in the teaching and learning process. The study revealed that physics classroom computer software enhanced the performance of pupils in kinematics in school physics more than when traditional approaches were used in the teaching and learning process. The study further revealed that the experimental group performed higher than the control group with the percentage difference of 10.5%. The findings are supported by Ghavifekr, and Rosdy (2015) who asserted that performance and improved cognition in academics by pupils have shown to increase when ICT is integrated in the teaching and learning processes.

The current study correlates with Behlol (2009) who found a significant difference between the mean scores of experimental and control groups on posttest, concluding that the achievement of experimental group, was significantly appreciable than control group.

Orora, Keraro and Wachanga (2014) conducted a study on effects of cooperative e-learning (CEL) teaching strategy on students' achievement in secondary school Biology. The study revealed that students who were exposed to CEL strategy achieved significantly higher scores in the BAT compared to those taught using conventional methods. The study further implied that the CEL teaching strategy was more effective in enhancing student's achievement than the conventional methods.

An earlier study conducted by Wachanga (2002) compared the effects of traditional and co-operative class experiment learning strategies on students' achievement and motivation in secondary school chemistry also found a significant difference in achievement. Students who were taught using cooperative class experiment methods were found to have higher achievement in Chemistry than those taught using traditional methods.

These studies support the results of this study which also encouraged pupils to work in small groups and were in constant collaboration with the teacher. However, in Wachanga's study, group rewards were based on the individual learning of the group members. This made students to make sure that every member of the group mastered the content in order to boost their group grade. In the present study, positive interdependence and collaboration was also emphasised which made students to take more time explaining various concepts and solving problems for one another using ICT tool interaction. However, the current study adopted an individual grade pattern. Thus, the achievement system was solely based on an individual and the pupils were tested individually and not as a group. This made the integration of ICT tools in the teaching and learning of genetics have a more positive influence in pupils' achievement in the experimental groups more than in the control groups that used traditional teaching and learning approaches only.

Arman (2013) carried out a study on the effectiveness of ICT approach on students' 8th grade achievement in mathematics in Palestine schools. He examined an experimental group of 48 students after studying a course that integrated the use of ICT in instruction. The students' achievement was examined before and after the experiment. The results indicated that there was an increase in the mean scores by a gain value of 8.94 after the ICT intervention. There was a significant difference in achievement at $p = 0.05$ level between the mean scores of the pre-test and post-test. The results are in collaboration with the current study were the performance of pupils within groups that were exposed to pretest and posttest in Table.4.2 and Table.4.3 also shows that the mean score performance of pupils in experimental group 1 was higher than pupils in the control group 2.

Accordingly, performance and improved cognition in academics by pupils have shown to increase when ICT is integrated in the teaching and learning processes (Ghavifekr, and Rosdy, 2015). This, therefore, demonstrates that integrating specific ICT tools as enhancement to traditional teaching and learning approach can address the challenges of students' poor performance in genetics.

5.2. Impact of ICT tools on pupils' performance in genetics as function of gender and age-group

Research studies conducted earlier have shown that gender, age group, quality of lecturing and interesting features of the teaching content influence pupils' motivation for work in certain subject (Lavonen *et al*., 2005). This section discusses the impact of ICT tools on pupils' performance as a function of gender and age groups, and further establish the interaction effects of gender, age groups and group names in relation to academic performance in genetics.

5.2.1. Differences in genetics performance as a function of gender and group names

The study revealed that there was a significant mean effect on gender and performance in genetics posttest scores when ICT tools were used in the teaching and learning of genetics. This implied that male and female pupils in the experimental groups performed better than male and female pupils in the control groups. However, the overall genetics posttest means scores on gender showed that male pupils performed better than female pupils. The results are constituent with general performance of male pupils in biology that indicate that boys' performance in biology and science subjects is better girls (ECZ, 2013; 2014; 2015; 2016, 2017).

The findings of the current study are in accordance with the finding by Eriba and Sesugh (2006) who revealed that boys outperformed girls in science and mathematics achievement. Ewumi (2011) also found a significant relationship between gender and students' academic achievement ($r = -0.21$; $p < 0.05$). The significant relationship indicated that the male participants achieved higher than the females.

Klein (2004) attributed the differences in scholastic achievements of male and female to biological causes and cultural stereotypes. In the current study, pupils in experimental and control groups also came from different socio-economic status. However, the pupils were being affected by similar culture values because they came from the same area (Kitwe District). Despite the pupils in both the experimental and control groups coming from different socio-economic status and sharing similar cultural values, the academic performance was higher in the experimental group as opposed to the control groups as shown in Figure 4.2. This showed that ICT integration had an impact on the performance of pupils in genetics posttest scores regardless of their gender, biological causes and cultural stereotypes in experimental groups.

However, it is not always true that male pupils outperform female pupils in sciences. Other studies have reported that males are becoming disadvantaged in schools, and fewer males are interested in science (Weaver-Hightower, 2003; Omoniyi, 2006). The results adhere to the current study were mean score for females in experimental group 2 showed a significant increase in performance in genetics posttest score when ICT tools were used in the teaching and learning of genetics compared to males of the same group and control groups as shown in Table 4.11 and Figure 4.2. Thus, the use of ICT tools in the teaching and learning of genetics had a significant impact on both males and female pupils' performance in genetics. Therefore, ICT tools have the potential to provide alternative interventions to bridge gender disparities in male and female pupil's performance in genetics and other science related subjects as was seen to improve the performance of male and female pupils in genetics in experimental groups.

When pupils have opportunities to interact among themselves, through the guidance of the teacher and using specific ICT tools in the teaching and learning of genetics, there is an improvement in performance, knowledge and skills across gender. This is evident in the results shown where the performance of pupils in genetics when ICT tools are used in both experimental groups differed across gender. For example, female pupils in experimental group 2 performed better than male students in experimental group 2 and control groups male and female pupils. Thus, integrating ICT tools in the teaching and learning of genetics can help to bridge the gap of gender disparities in the performance of pupils in genetics (biology).

The results correlates with the study by Olukemi (1998) that revealed that the cognitive power necessary for science endeavours is not foreign to girls. He further asserted that science ability correlates highly with general intelligence in which no consistent gender differences were found. This implies that no gender has advantage over the other in science achievement. Hence, the ICT tools that were used in the teaching and learning of genetics helped to bridge the gap on gender disparity as can be seen on the distribution of gender and performance in group names in Table 4.11. Results further indicate that ICT tools have a greater potential in transforming the gender achievement disparities in genetics when these ICT tools are used in the teaching and learning of genetics.

Well, results of the current study corroborate with the findings of Afuwape (2011) who indicated that there was no significant gender difference in achievement. However, female students were found to be slightly better with a mean score of 16.13 in basic science than their male counterparts whose mean score was 16.07. He further asserts that there are no longer distinguishing differences in cognitive, affective and psychomotor skills achievement of students in respect to gender. These findings also correlate with the theoretical frame that advocated that through the use of instructional scaffolding theory in the integration of ICT tool in the teaching and learning of genetics, there is an improvement in the cognitive, affective and psychomotor skills achievement of pupils with regard to gender.

According to FAWE (1998) girls' achievement was much lower than that of boys partly due to their poor attitude towards science. It also indicated that teachers in normal competitive classes use discouraging remarks on girls' participation in learning science (FAWE, 1998). In the current study, the researcher treated and gave support to every participant equally so that gender disparities could be minimised as guided by the theoretical framework.

Gender disparities in academic performance in science have been attributed to a series of reasons. According to UNESCO (2004) teachers often consider girls as less intelligent and destined to less well-paid jobs than boys. Girls are also given little praise compared to boys. According to FAWE (1993), low self -esteem, poor self-image, non-assertive behaviour among girls and poorly trained teachers contribute to their shying away from science and mathematics. FAWE further asserts that girls believe boys are more superior and intelligent and more capable of handling difficult subjects. Boys in turn perpetuate this myth by dominating in most of what they consider to be "masculine zones" such as computer rooms, science laboratories and technical equipment or engineering laboratories. In the current study, all the pupils were provided with the same opportunities and interaction within themselves and with the researcher. This was to ensure equal learning opportunities among pupils during the teaching and learning process of genetics.

Thus, the use of ICT tools in the teaching and learning of genetics conferred advantage over gender disparities, and consequently on the improvement of cognitive, affective and psychomotor skills in pupils.

5.2.2. Differences in genetics performance as a function of age group and group names

Table. 4.14. shows insignificant interaction of group names and age group on the performance of pupils in genetics posttest scores. The findings revealed that the performance of pupils in genetics posttest scores were not affected by any interaction of age group and group names. The results are consistent with Shaheen and Khatoon (2017) whose findings also showed insignificant interaction between subgroups (experimental and control groups) on achievement posttest in biology.

The current study further showed that there was no significant mean effect on age in genetics posttest score when ICT tools were used in the teaching and learning of genetics. This showed that the performance of pupils on posttest in group names did not dependent on pupils age groups. However, pupils in the experimental groups performed better than pupils in the control groups as shown in Table 4.13 and Figure 4.3. The results are in line with Shaheen and Khatoon (2017) who also found that age groups of biology students had no significant impact on the achievement posttest score in biology. Their study also revealed that experimental groups students performed better than control groups students.

Bulić, Jelaska and Jelaska (2017) findings clearly indicated that the age-factor is a significant predictor of success, regardless of pupils belonging in the experimental or control group. However, the current study revealed that the mean posttest scores on genetics was higher in experimental groups than in control groups contradicting Bulić, Jelaska and Jelaska (2017) findings that the age of the pupils was in favour of the application of e-learning in the second educational cycle as the factor of age was identified as the predictor of efficient e-learning, in teaching. Table 4.13. and Figure 4.3 shows that all age groups in the experimental groups performed well. Thus, age is not a predictor for efficient e-learning which in this case is the integration of ICTs in the teaching and learning of genetics.

The current study also contradicts Didia and Hasnat (1998) who found that age, as a measure of maturity, had a significant influence on performance. Thus, according to the current study, age is not a measure of maturity and does not influence performance. The researcher in the current study thus argues that information can be split and explained into simple concepts to any pupil of any age group through instructional scaffolding and any pupils is able to learn a concept and perform better. Through the use of instructional scaffolding, pupils in the experimental groups were able to perform better than those in the control groups despite their age groups. Thus, integrating ICT tools in the teaching and learning of genetics helped to link the age discrepancy in genetics performance among pupils of different age groups in the experimental groups.

It is important to note that ICT tools provide the most basic teaching and learning tool for genetics as it is able to grow the Formal Operational Stage as cited by Piaget (1977) in cognitive development theory. Pupils can easily absorb and construct abstract concepts in genetics through the use of ICT tools to visual objective reality that provides meaningful learning in the teaching and learning of genetics. Thus, the age as a factor in performance can be influenced through ICT tools as seen from the differences in mean performances in experimental and control groups.

5.3. Attitude of pupils towards the use of ICT in the teaching and learning of genetics

5.3.1. ICT increases interest in learning genetics

The results of the study showed that the use of ICT in the teaching and learning of genetics has a positive effect on pupils' interest. Table 4.15 showed that most pupils appreciated the use ICT tools as an interesting experience and further agreed that ICT tools increased their degree of interest in genetics the teaching and learning process. The results of the current study correlate with the findings of these studies that revealed that teachers use of computers, visual materials like charts, posters and models, were found to be effective for making the lessons attractive and interesting for students (Mistler-Jackson and Songer, 2000; Paul and Fernandez, 2000).

The study further revealed that pupils have vast knowledge on ICTs but their teachers do not utilised the pupils' potential in ICTs to make teaching and learning of genetics more interesting. Thus, pupils contended that if teachers were able to tap into their potential in the teaching and learning of genetics, genetics would even be more interesting to learn. The study showed that pupils already have the interest in ICTs and all they need is collaboration between the teacher and specific ICT tools that can be used in the teaching and learning of genetics.

5.3.4. Pupils access to ICTs in schools

Adoption of ICTs as a means to provide access and continuity must begin by breaking up the digital divides of a society that has not internalised adaptation dynamics yet. With pupils showing interest in using ICTs in the teaching and learning of genetics, the MoGE and other stakeholders need to improve, equip and install modern ICT in schools if the vision 2030 is to be realised: which is to enable all school in Zambia to have access to ICTs by 2030 (NICP, 2006). However, there is poor access to ICT facilities in schools, and pupils do not participate in any school activities that involve the use of ICTs in schools, especially in the teaching and learning of genetics. Furthermore, the school ICT laboratories are equipped with old refurbished computers that cannot allow new software versions to be installed on them. This was seen in the exempt where one interviewee stated that:

> *ICTs in schools are poorly equipped that its hardly possible to install latest computing technologies (softwares) on them. Most*

of the computers in schools have old version programmes that cannot accommodate new and upgraded computer softwares. This also has contributed to us pupils not engaging ourselves in the learning of genetics and any other biology topics using ICT tools. I remember one teacher wanted us to research on some projects for Junior Engineers Technicians and Scientist (JETS), but computers just failed to connect to the routers he provided. So we relied on the teachers' laptop. Besides, we are not allowed to have access to the computer laboratories.

Pupils are part of agents of change in the education sector, and as such, should be given access to all ICT facilities in schools, especially in the teaching and learning of genetics because they are born in the technological age. Cabero (2010) concretises the notion asserting that students participate as new educational agents, who have become a major element for communication and social interaction as a result of being born in a high-tech society.

Some researchers have agreed with the current findings, and have stated that some of the major impediment to ICT use in schools have been attributed to inadequate ICT infrastructure and poor access to ICTs (Ang'ondi, 2013; Mewcha and Ayele, 2015). Furthermore, the current situation showed that access to ICT is a major requirement for participation in a technological society (Tello, 2007). Therefore, adoption of ICTs as a means to provide access and continuity must begin by breaking up the digital divides of a society that has not internalised adaptation dynamics yet, beginning with the education systems at the grass root. SNDP (2011) objective in education is directed at increasing access to ICTs and quality education. This can only be achieved by providing and allowing pupils to have access to ICTs at school levels such as Wi-Fi, electronic gadgets (laptops, smart phones, iPads) for the purpose of research. Restocking school computer laboratories with modern computers and other ICTs such as offline interactive academic softwares, smart boards and projectors.

Pupils contended that if access to ICTs improved, their attitude towards its use in the teaching and learning of genetics would be more positive.

5.3.5. ICTs encourages pupils to be active and more creative

Table 4.15, results of the study also showed that the use of ICT tools in teaching and learning of genetics enabled the pupils to be more active, and engaging in discussions with others more than in the traditional approach learning environment with the mean score of 4.67. Furthermore, pupils strongly agreed (78 [41.9%]) that the use of ICT in the teaching and learning of genetics made them to be more creative with the mean score of 4.64. As pupils become more creative, other metacognitive spheres of reasoning and the way of handling problems in genetics develop and improve significantly. This in turn makes learning and teaching of genetics in classroom settings more user friendly. The results are in line with the research findings by Macho (2005) that revealed that students learn more effectively with the use of ICT as the lesson that designed are more engaging and interesting. Macho (2005) further argued that using ICT in education would enhance students' learning and that ICTs fosters learning among students. The findings of the current study also correlated with Maimum *et al* (2011) whose study looked at integration of ICTs in the teaching of Islamic Religious subjects, the findings revealed that ICTs may be used as a medium of teaching and learning to develop a more creative thinking in the integrated education process.

The study by Zhang (2013) further argued that ICT helps students to be more creative and imaginative as their knowledge paradigm expand; and ICT helps students to possess all four skills in learning when they are able to acquire necessary information and knowledge. The results are similar to the current study that showed that pupils found that ICT tools allowed them to understand complicated concepts in genetics and that information was clear when ICT tools were used in the teaching and learning processes as showed by the means scores of 4.88 and 4.49 respectively. This is because ICT tools provide dynamic tools that can be used to present similar information in difference way so as to reinforce comprehension in the teaching and learning of genetics, thus pupils are able to learn and view a concept in genetics in different modes. The finding also correlated with Gee (2007, 2011) studies that revealed that ICT fosters pupils' creativity and improves both teaching and learning quality.

5.3.6. ICTs increases the level of motivation in pupils

In this study pupils also strongly agreed (78 [41.9%)] that their levels of motivation on genetics increased when ICT tools were used in the teaching and learning of genetics with the mean score of 4.47. An increase in motivation by pupils results in build-up in confidence in approaching certain aspects of life, in this case, the attitude towards learning genetics using ICTs. The confidence acquired can then be directed to improved academic performance and interpersonal dialogue during group works as pupils are engaged in teaching and learning of genetics. Through motivation, pupils engage themselves in deductive reasoning and go an extra mile to formulating hypotheses that act as tools to help them arrive at a better solution in the teaching and learning of genetics using ICTs. It is important to emphasize that pupils' motivation for work and learning is one of the most important components that has an influence on the acquisition of learning outcomes. According to Pelgrum, (2001) motivated pupils are more successful in mastering the teaching contents because they are active during classes, they question, follow experiments, research, use modern ICT tools and are involved in different project activities. This results in pupils' enhancement in confidence towards genetics as they use ICTs in the teaching and learning of genetics.

These findings are in line with William (2004) who clearly demonstrated the potential of ICTs to increasing motivation and autonomy in learning and teaching. He further argued that ICT improve retention of knowledge and skills.

In a separate study, William (2008) further avows that it has been observed that when students collaborate in pairs on computers or other ICTs, they experience greater autonomy and self-direction, and teachers become less directive. This is in line the findings in the current study where pupils strongly agreed (79 [42.5%]) that using ICT tools in the learning and teaching of genetics allows one to discuss genetics with other more than when using the traditional approach method with the mean score of 4.67. In doing so, pupils tend to experience independent learning which, in turn, fosters confidence in the learning process among themselves. Zhang (2013) study also indicated that students can develop the confidence to have better communication and able to express their thoughts and ideas better when ICTs are used in the teaching and learning process.

Another study by Saverinus and Williams (2008) showed that when ICTs are used in education, it has increasing positive effects such as increased motivation among pupils, autonomy in learning and improved retention levels among leaners. Additionally, the study also revealed that an increased motivation can raise positive attitudes in pupils. Saverinus and Williams (2008) study correlated with the findings of the current study as pupils also showed an increased level of motivation.

5.3.7. Pedagogical use of ICT tools

The integration of ICT into education has become a process whose implications go far beyond the technological tools nurturing the educational environment (Hernandez, 2017). The ideas of teaching construction and the way one can build and consolidate meaningful learning based on technology are now being discussed, or the technological use of education, in strictly pedagogical terms (Díaz-Barriga, 2013). The study revealed that the use of ICT tools in the teaching and learning process can be used to improve the delivery of the abstractness content of genetics by bring realism in classrooms. Pupils believed that genetics content can be presented in different multimodal (hearing, audio and video). And as such, pupils also believed that the use of ICTs can be excellent supplements of teaching and learning aids that can provide genetics with a lot of advantages such as bring realism in the teaching and learning of genetics, smooth content delivery, providing less intimidating environments for learning genetics to weaker pupils, fostering creativity, providing higher academic comprehension and retention in genetics.

Other research studies have indicated that students remember best those ideas or concepts that are presented in ways that are related to their sensory channels, for example, audio and visual representations in form of pictures, charts, models and multimedia teaching. The studies further argued that providing information in such different modalities provide more concrete meaning to words, show connections and relationships among ideas explicitly, provide a useful channel of communication and strong verbal message and memorable images in students' (Cyrs, 1997, Çimer, 2004, 2007).

Some of these findings are in line with the results of the study by Mulima, (2013) which showed that ICTs were valuable pedagogical tools in enhancing the teaching and learning of the Religious Education (R.E). The study further revealed that ICTs were perceived to help pupils learn better, promote participation, ambiance transformation in class, creativity, motivation, easier understanding, and higher retention levels among pupils in religion studies.

Additionally, the study also revealed that the use of ICT tools in the teaching and learning of genetics broadened the array of resources to use in the teaching and learning processes. Most pupils indicated that ICT tools have the potential to provide different types of resources for preparation and delivery of content to pupils within and outside the lessons. Resources that can be used to present lessons on genetics outside class schedules hours include the following; instant messenger applications (such as WhatsApp messengers, Imo, viber, Duo, emails, Moodle, live-chats, and blogs), web-links for simulations, YouTube video and audios while those that can be used within classrooms include academic software (Gene-X simulation software,), YouTube videos, and Microsoft applications (excel, word) can provide means through which content of genetics can be delivered to pupils simplify the content of genetics. According to Aguilar (2012) the transformation of ICT has allowed ICT tools to become educational tools that could further improve the educational quality of the student and revolutionise the way information is obtained, managed and interpreted.

The implications of the growing accessibility of mobile technologies (in the form of smart phones, iPads, iTunes and smart watches), hand held digital assistants and universal laptop-computer is that, there is an increasing affordance for pupils to work more continuously across home and school settings, in activities to be initiated outside the school, or practice on exercises to be undertaken when or where desired (Passey, 2010). This means that ICT tools have the potential to go beyond the classroom environment. The teacher can continuously scaffold pupils that are lagging behind in the formal classroom setting by explaining and answering relevant questions in genetics through mobile technologies and other digital and universal laptop-computers across wireless networks.

Moreover, the mobile devices come equipped or ready for social media applications like Facebook, Twitter, Wikipedia, YouTube, WhatsApp, Telegram, Instagram, Snapchat 'which are part of what is known as Social Web 2.0, best characterized by the notions of social interaction, content sharing, and collective intelligence' (Alabdulkareem, 2015: 214). Educator perspectives have been raised on adapting these kinds of tools and creative media skills for engaging students 'to become the authorities on subjects through investigation, storytelling, and production' (NMC-CoSN, 2016.18). For example, students and teachers in New Zealand and Singapore are using WhatsApp as a platform to build intercultural understanding and to foster longer term teacher collaboration towards meeting student 21st century learning needs (Asia New Zealand Foundation, 2016). Similarly, social media platforms like Twitter are being used by teachers and students in a multiplicity of ways, for example: to discover new information; to generate discussion, interest and collaboration; to connect with local and global issues; to explore, exchange and publish thoughts, ideas and perspectives; to communicate information and join professional learning networks (Shannon *et al*., 2011; e-Learning Industry, 2016).

In a "Meta-Review of the effects of Innovative Science and Mathematics", Savelsbergh *et al*. (2016) describe studies of ICT-rich teaching approaches inclusive of (individualised) computer-based instruction, games, feedback, interactive quizzes, computer based labs, simulations and robotics as leading to gains in more positive attitudes where 'students enjoy working with computers, students feel more safe to experiment and make mistakes, and/or students appreciate the (quick) feedback'.

Table 4.15. also shows that pupils highly recommended ICT tools as pedagogical tool in the learning of genetics with the mean score of 5.04. and further strongly agreed (94 [50.5%)] that pupils would like to be taught genetics with the use of ICTs than learning genetics using

traditional approach only with the mean score of 4.81. This is because most ICT tools are more grounded and provide answers to ‘why?’, ‘what’, and ‘how’ questions surrounding the concepts of genetics through; mediation of imaginary concepts to visual concepts, design genetics virtual experiences and environments for pupils. Loveless (2011) however relates on more recent research into the role of technologies for enhancing ‘good pedagogical design’ to express congruence between content and implementation (teaching strategies, learning environment, assessment and feedback, underlying learning theories). The author defends educator technology use as grounded in ‘Why?’, ‘What?’ and ‘How’ questions around their vision and beliefs about ‘why they think their practice matters and how they can best design experiences and environments for pupils.’ Examples of technology use for deeper learning include the European Union (EU) Go-Lab project and online portal offering innovative, interactive, collaborative and context-aware tools and functionalities that provides a student-centred interface to promote contextualised and adaptable learning experiences (EU-Go-Lab, 2017).

Xenofontos *et al*. (2016) report on research findings illustrating the capacity of the Go-Lab interactive learning system (ILS) to facilitate the advancement of content knowledge, while the authors report that the development of inquiry skills would require longer duration of experiences with such learning environments. The current study also revealed that among the factors affecting teachers’ attitudes towards the use of ICT tool in the teaching and learning of genetics where lack of ICT technicians and specialists in schools. Teachers further avowed that they were lacking knowledge and skills on the usage of ICT tools in the teaching and learning of genetics. Thus, the absolute pedagogical use of ICT in the teaching and learning of genetics to pupils will require some ICT training or CPD in schools or districts among teachers of biology.

From the United states (US), Dede (2014) describes the EcoMUVE (multi-user virtual environment ecosystem) middle grade curriculum initiative engaging students to assume the role of scientists, investigating research questions by exploring the project virtual environment and collecting and analyzing data from a variety of sources over time. Findings from the project research showed that while students were initially preoccupied with the technology interface of itself, with time they became ‘increasingly engaged in the student-led, collaborative inquiry experiences afforded by the embedded scientific investigation’ (Metcalf *et al*., 2014). Thus, ICT tools can play a pivotal role as a pedagogical tool in the teaching and learning of genetics, and in turn positively affect the attitudes of pupils towards it use.

5.3.8. ICTs helps in learning and understanding of genetics

Since ICTs provides pupils with good pedagogical practices and experiences, pupils strongly agreed (75 [40.3%]) that ICT tools made them to understand the concept in genetics better than when traditional approaches were used with the mean score of 4.68, as shown in Table 4.15. This can be seen from the Table 4.16 where the experimental groups attitude mean scores were higher than the control groups. And because of the good pedagogical practices that ICTs offers to pupils, pupils were able to learn more things using ICT than when using traditional methods of teaching. This is also revealed on Table 4.15 were pupils strongly agreed (80 [43.0%]) that they learnt more things about genetics through the use of ICT tools than they learnt using traditional methods. According to Ayala (2012) ICTs, as technological tools, have increased the degree of significance and educational conception, establishing new models of communication, besides generating spaces for training, information, debate, reflection, among others, as well as breaking up the barriers of traditionalism in the classroom.

The current study found that ICT provide platforms for effective learning and assimilation of genetics concepts. Through the multiple resources that ICT tools were able to provide to pupils in the teaching and learning of genetics, pupils were able to learn and understand genetics better in the experimental groups than in the control groups, Thus, pupils held a positive view that ICTs facilities provides the platform through which information can be delivered to learner using different ICT resources and making pupils to learn more things in genetics than they could understand using traditional approach.

Furthermore, pupils contended that it was not enough to teach, learn and understand genetics using the black boards and static models, there was need to integrate ICTs in the teaching and learning of genetics. The results of the study collaborated with Granados (2015) who argued that the use of ICT means breaking with traditional media, boards, pens, etc., and giving a way to a teaching role based on the need for training in and updating one’s knowledge of teaching methods based on current requirements.

The current study revealed that pupils needed and hoped that their teachers adopted ICT tools in the teaching and learning of genetics; as teaching and learning aids, in explaining concepts that are perceived to be complicated to be understood by pupils, to provide extra works outside classroom hours and to engage pupils in research. This was because pupils found ICT tools as engaging and suitable tools for learning and understanding genetics concepts.

The findings are in line with Becker (2000) study that revealed that ICT was found to increase students' engagement, which leads to increased amount of time students spend working outside class time.

5.3.9. Pupils overall attitude mean scores towards genetics

The pupils' overall attitude mean scores showed that all pupils had a positive attitude towards ICTs, (Figure 4.4), in the teaching and learning of genetics across all group names. The findings are in line with Yang and Kwok (2017) study which indicated that all 737 participants who answered the questions on the questionnaire showed positive attitude to the constructs that were measured in this study. According to the study, all means were above the midpoint of 3.0, ranging from 3.47 to 3.80. The small standard deviation values ranged from .81 to .90, indicating a narrow spread of item scores around the mean. The results showed that pupils are eager to embrace the use of ICTs in the teaching and learning of genetics, despite them belong to the either control or experimental groups.

However, the results of the current study showed that ICT tools that were integrated in the teaching and learning of genetics had a significant impact on pupil's attitudes in genetics (Table 4.17). The results showed that there was a significance difference in pupils' attitude scores between groups, implying that the attitude of pupils towards the use of ICT tools in the teaching and learning of genetics differed for different group names (control 1 and 2 groups, and experimental 1 and 2 groups). Thus, pupils who were in the experimental groups showed a more positive attitude towards the use of ICT tools in the teaching and learning of genetics than those that were in the control groups. This was because pupils in the experimental groups were exposed to different learning modalities and resources during the teaching and learning of genetics. Thus, exposing pupils to different ICT resources in the teaching and learning of genetics has a significant effect on learners' attitudes.

The findings are in line with other research studies that have shown that different learning modalities integrated technology into the classrooms have effects on pupils' attitudes and learning processes. These research studies have shown that ICT provides pupils with a learner-centered environment, opportunities to make decisions and to develop critical thinking skills, opportunities to build new knowledge, analyse, synthesise and assess data and learning materials, (Castro, Sánchez and Chirino-Alemán, 2011; Fu, 2013; Lu, Hou, and Huang, 2010; Chai, Koh, and Tsai, 2010). Additionally, ICTs allows students to learn through discovery and inquiry, and to solve problems. Autonomy, capability, and creativity are the three characteristics that enhance learning (Fu, 2013; Lowther *et al*., 2008). It is critical to note that the three characteristics arise from the pupils increased attitude when they are exposed to different learning modalities through the use of different teaching and learning resources, in this case, ICT tools.

It can then be asserted that pupils in this current study showed a positive attitude towards use of ICT in the teaching and learning of genetics because they believed that ICT could allow them to control their learning, become more creative, improve confident, to learn more things in genetics, to experience another new learning environment and to learn through collaboration.

5.4.1. Attitude of teachers on the use of ICT tools in the teaching and learning of genetics

5.4.2. ICTs improve teachers' abilities in the teaching and learning of genetics

Successfully integrating ICT into education depends to a larger extent on the teacher's ability to structure the learning environment (UNESCO, 2008). The study revealed that teachers' ability and increased motivation in the teaching and learning of genetics using ICT tools were affected by their attitudes towards ICT usage. The study showed that teachers had a positive attitude towards ICT use in the teaching and learning of genetics (Figure 4.5). The results of the current study collaborated with Yoloye (1990) and Yusuf (1998) studies that revealed that educators had positive attitude towards the use of computer education and were willing to be trained in the use of computers. Another study by Sánchez *et al* (2012) revealed that teachers showed a positive attitude towards the use of computer tools with the score of 3.83 (from 1= strongly disagree to 5=strongly agree).

Furthermore, teachers avowed that engaging pupils and using different ICT tools in the teaching and learning of genetics with the things they are familiar with (ICT tools) helped pupils to grasp their attention, improve their motivation, stimulate pupils' positive attitude and improve their performance in genetics. Therefore, ICT tools were found to be excellent tools that increased teacher's abilities in the teaching and learning of genetics.

Sánchez *et al* (2012) further revealed that teachers were ready to continue using computer tools inside the classrooms. This made the researchers understand how and why most of the teachers were ready to continue learning computer tools for their use inside the classroom because they considered that computer tools were helpful to keep pupils' attention, improve the intervention with pupils with learning difficulties and also improve the motivation and academic performance of both teachers and pupils.

5.4.3. ICTs as good supplementary pedagogical tools

The current study showed that teachers recommended ICTs to be good supplementary pedagogical tools that could be used to manage lesson, time cost-effective, explain abstract concepts (DNA replication, cell division and genetic crosses) and solve problems in genetics better with instant feedback in most cases (excerpt 11). Experiments and practical works that are almost impossible to be conducted in the school science laboratories with quick feedback, such as those that show mutations or pose a serious threat to health of both teachers and pupils, can be simulated using ICT tools with zero tolerance of contamination and failure. Furthermore, ICTs can be used in teaching lessons in genetics in more than one modality (video, audio, text, and audio-video) and much better than using Traditional methods of teaching.

The findings of the study are in line with Alkahtani (2017) who revealed that ICT is believed to enhance work and education in other ways. He further argued that ICTs can be used to deliver lessons with interesting and enjoyable real-world examples, and stimulating visual and audio illustrations from an extremely wide range of sources. In addition, ICT offers well-known benefits such as efficient new ways to compose documents and organize and store information. Email helps teachers and students communicate outside of class, holding online tutorials or submitting or returning homework, as well as allowing teachers and students to share their ideas with teachers and students in other schools. Dedicated software can be used for students with special needs.

Further, the findings are in line with Fu (2013) who found that ICT facilitates learning without the boundaries of time and Place. ICT provides abundant resources such as videos, visual presentation, and online materials. For example, online course materials and teleconferencing classrooms foster simultaneous interaction between the learner and the teacher and among the pupils themselves (Heemskerk, Volman, Admiraal, and ten Dam, 2012, 155). Isling-Poromaa (2015) further asserts that ICT gives educational equality due to its motivating effects and its ability to differentiate teaching. Thus, ICTs are good supplementary pedagogical tools that can be used in the teaching and learning of genetics. Therefore, it is imperative that teachers adopt the use of ICT tools in the teaching and learning of genetics.

The finding of the study collaborated with Player-Koro (2012) whose study revealed that ICT is a powerful force required for educational reform. The study further revealed that ICT is effectively used in classrooms for instruction, knowledge, and assessment and is needed for educational reform. The findings are also in line with Stošić (2015) who reported that educational technology improves the quality of education since it includes instructional materials and the behavior of all participants in the educational process (item J on Table 4.20). Additionally, ICT can improve educational quality and associate learning to everyday situations (Lowther, Inan, Daniel Strahl, and Ross, 2008). Husain (2010) findings revealed that teachers thought that using ICT skills in developing and presenting information was essential technical competency that teachers need to acquire.

However, ICTs as excellent pedagogical tools does not come without any demands from the teachers. There is need for teachers to put up an extra effort and creativity in achieving this objective. It is imperative then, that teachers need to be well vested in ICTs if they are to integrate them in the teaching and learning of genetics.

5.4.4. Teachers knowledge and skills on ICT

Teachers' knowledge and skills on ICTs have effect on their attitudes towards ICT use in the teaching and learning of genetics. The study revealed that most teachers had inadequate knowledge on ICTs and could hardly integrate the ICTs in the teaching and learning of genetics. However, teachers were familiar with some of the ICTs such as laptops, projectors, Wi-Fi, social media and Microsoft software. (excerpt 1 and 2). Further, the results revealed that teachers' competence in the use of ICTs was limited to typing lesson plans, printing and storing information on biology (e-books pdf) but they did not use the available ICTs such as projector and Microsoft package softwares in the teaching and learning of genetics (excerpt 3 and 5).

The study collaborated with Tezci (2010) findings that revealed that ICT use in classroom is limited, a finding which is attributed to the level of experience. Tezci further argued that the most commonly used ICT types were the Internet, e-mail, word processing, and educational CDs. According to Tezci (2010) teachers' low levels of software use for educational purposes might be strongly influenced by their low levels of expertise and lack of knowledge and experience about how to use and adapt themselves to the program. As a matter of fact, this result is confirmed by the fact that teachers have a low level of ICT knowledge. For this reason, most teachers were not exploring other possibilities of teaching genetics especially using ICTs (excerpt 4). Consequently, some teachers believed that ICT tools were difficult to learn and understand because they lacked knowledge and skills on how to utilise them in the teaching and learning of genetics.

It is imperative then that teacher be given some form of ICT education and educational softwares that can be used in the teaching and learning of genetics for the purpose of equipping them with ICT knowledge, skills and resources.

5.4.5. Lack of teacher training in ICTs

The low levels of knowledge and skills in ICT by teachers might result from the fact that these technologies require technical knowledge. The study revealed that teachers lack of training in ICTs was another factor that was impeding its use in the teaching and learning of genetics. Teachers have no formal or informal training in ICTs except those that the government had selected and sent for fast-track training workshops so as to provide man-power for computer studies, the new subject that was introduced at junior and senior secondary school (excerpt 8)

Tezci (2010) argues that there is a significant correlation between the levels of knowledge about ICT and the use of ICT in education. His study revealed that the higher the level of knowledge on ICT, the higher its level of use in education. Another finding supporting this result is the significant differences observed between teachers in terms of their previous participation in a computer course. The study also showed that teachers who had participated in the computer course showed a positive attitude towards ICT use in the teaching and learning of genetics than those that had not participated in any computer course.

Other researchers have suggested that teachers should receive training on the effective strategies and tools that can allow technology integration into classrooms (Almekhlafi and Almeqdadi, 2010) and improve curricula with technology-boosted materials (Goktas, Yildirim, and Yildirim, 2009; Hutchison and Reinking, 2011).

The current study resonated that if the knowledge and skills of teachers on the use of ICTs in the teaching and learning of genetics were addressed well through ICT training, then the attitude of teachers towards ICTs as a difficult tool will be erased. This was seen in excerpt 8 that teachers viewed the use of ICTs in the teaching and learning of genetics as difficult due to lack of CPD lessons (training) across the entire education system. This predicament could be resolved by introducing CPD lessons at all levels in the education sector or by engaging ICT specialist in collaboration with biology educationist to formulating an education policy in biology that stipulated user friendly ICTs tools with guidelines so that teachers can easily assess the ICT tools either online or offline.

Other research studies on ICT as demonstrated by Anderson (2006), Bove´e, Voogt and Meelissen (2007), İşman, Evirgen and Çengel (2008), Paraskeva, Bouta and Papagianni (2008) revealed that the higher the mean level of knowledge, the more the ICT use. These studies emphasised that teachers with previous computer experiences have higher levels of knowledge on ICT, and their ICT use was more frequent. Accordingly, teacher's levels of ICT use showed that they used these technologies as information transmission-based tools and not as teaching and learning resource tools because of lack of ICT training and the know-how of how the available ICT tools could be integrated in classroom activities.

However much the teachers were familiar with some ICTs, they were not using the ICT tools in the teaching and learning of genetics because of lack of teacher training on ICT use as seen in excerpt 1 and 2. The findings are line with Sarangi (2003) and Alkahtani (2017) whose study revealed that educators had a limited idea about how the available ICT equipment could be used in teaching-learning situation. Their findings were attributed to the poor training opportunities for teachers to develop the necessary ICT skills.

5.4.6. Challenges on the use of ICTs

The study revealed that factors such as poor and inadequate ICT laboratories, no curriculum framework with specific ICT tools to use in teaching genetics, no teacher training in ICTs, no and/or inadequate ICT technicians in schools contributed to negative attitude of teachers and poor use of ICTs by teachers in the teaching and learning of genetics.

The results collaborate with Sánchez *et al*, (2012;) who revealed that teachers have difficulties in ICTs due to; lack of educational resources, implementing the training contents into their practice, difficulties in practical implementation of ICTs, lack of specific programs to apply in the subject taught, scarce institutional support (absence of computer technicians in the school to support teachers), lack of time in class to use ICT, lack of motivation. These challenges affect teachers' attitudes towards the use of ICTS in the teaching and learning of genetics.

Other research studies also revealed that ICT provision and facilities in schools were found to be poorly equipped to deliver ICT, not least because some still operated in "rented houses" (i.e. in buildings that were not purpose-built to serve as schools), shortages of computer equipment (Abatain, 2001; Alshowaye, 2002).

The findings of the current study correlated with Bingimlas (2009) and Mewcha and Ayele (2015) findings that showed that teachers had a strong desire for the integration of ICT into education but they encountered many barriers. The major barriers were lack of confidence, lack of competence and lack of resources. Since lack of confidence, competence and accessibility have been found to be the critical components of technology integration in school. According to Bingimlas (2009) ICT resources including hardware and software, effective professionals' development, sufficient time and technical support need to be provided to teachers. No one component in itself is sufficient to provide good teaching. However, the presence of all components increases the possibility of excellent integration of ICT in teaching and learning opportunities.

5.4.7. Overall teachers' attitude mean score towards ICT use in the teaching and learning of genetics

The study showed a positive overall teachers' attitude towards the use of ICT tools in the teaching and learning of genetics. This implied that teachers were agreeable to the use ICTs in the teaching and learning of genetics despite the many challenges that they were facing in its use and implementation in classroom activities.

The findings of the current study are in line with Mehra and Newa (2009), Husain (2010) and Ndibalema (2014) whose study revealed that teachers exhibited positive attitude towards the use of ICT. The studies further asserted that ICT must be given higher priority in teacher education curriculum, so that the future teachers can cope with various challenges in education system and more specifically the new roles of teachers in ICT based teaching-learning systems.
Contradicting the present findings, Hew and Brush (2007) found negative attitudes of teachers towards ICT, and Sarangi (2003) also found that teacher educators have a low positive attitude for ICT though not negative. However, it is beyond any reasonable doubt that ICT use in the teaching and learning of genetics have a positive effect on teachers' attitudes as most teachers were enthusiastic to learn and explore different ICT tools that could be used in the teaching and learning of genetics.

5.4.8. Difference in teachers' attitude of integrating ICT tools between gender

The study showed that gender was found not be a significant factor in determining the attitude of teachers towards the use of ICT in the teaching and learning of genetics. This could be attributed to poor teacher experiences with ICTs, lack ICT hardware and software for genetics in schools and across the education systems. The results of the study did not collaborate with the studies by Volman, van Eck, Heemskerk and Kuiper (2005) and Bove´e, Voogt and Meelissen (2007) who demonstrated that females had more positive attitudes than males.

The study further revealed that teacher held high motivation, creativity and recommended the use of ICTs in the teaching and learning of genetics. However, what was affecting their use of ICT were unequal distribution of ICT equipment, lack of ICT training, poor guidelines on the objectives and learning outcomes of the curriculum and school culture that affected both genders in their attitudes towards ICT use in the teaching and learning of genetics. Further, all teachers had the same experiences of ICTs, they lacked knowledge and skills on ICT use in the teaching and learning of genetics.

5.5.1. Implication of the instructional scaffolding to the study

If pupils were involved with guidance from their teachers in the teaching and learning of genetics using ICTs, their performance and attitudes could improve positively. This is in support of the instructional scaffolding authored by Wood, Brunner and Ross (1976). Thus, using instructional scaffolding the researcher organised appropriated ICT tools for each subtopic in genetics that were being used as guide to build the pupils with confidence, creativity, interest and motivation in the teaching and learning process. Further, pupils were fully engaged in all aspects of learning through interaction with the researcher and the ICT tools and within themselves. Frustrations on the poor ICT tools were well handled by the researcher through guidance, demonstrations, encouragements, motivation and researcher-pupil interaction. Thus, it can be inferred that teaching and learning through ICT tools is more effective than using traditional teaching approaches only. Having used this theory in the context of the current investigation, the researcher is of the view that this could work towards addressing the issue of poor performance and negative attitude of teacher and pupils towards genetics.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1. Overview

In this chapter, the researcher presents the conclusion from the main research findings which answered the research questions, and finally recommendations are given. Integration of ICT in education is one of the areas that requires the attention of every scholar who aspires for quality implementation of biology 5090 syllabus in the teaching and learning processes in school.

It is important to note that the study examined the integration of ICT in the teaching and learning of genetics in two secondary schools of Kitwe District. The researcher wanted to establish; how ICT tools can be used to enhance pupil performance in genetics in Biology at two selected schools in Kitwe district when it is used as an enhancement to traditional teaching learning methods, the impact of ICTs on pupils' performance in genetics as function of gender and age group with respect to group names, and finally the attitudes of pupils and teachers on the use of ICT in the teaching and learning of genetics. The researcher in the sub-sections below presents the conclusion and finally recommendations.

6.1.1. Use of ICT tools to enhance traditional teaching-learning methods so as to improve pupils' performance in genetics

The study established that pupils performed better in genetics in those group names that used ICT tools as an enhancement to traditional teaching and learning method than in group names that did not use ICT tools in the teaching and learning process. Based on the findings, it can be concluded that ICT tools improves pupil's performance in genetics when they are used as enhancement to traditional teaching and learning methods.

6.2.1. Impact of the use of ICTs on pupils' performance in genetics

6.2.2. Differences in genetics performance as a function of group names and gender

The study established that the performance of pupils were not affected by any interaction of gender and group names. However, there was a significant mean effect on gender on pupils' performance in genetics posttest scores when ICT tools were used in the teaching and learning of genetics. Furthermore, the use of ICT tools had an effect on the performance of males and females' pupils in the experimental groups than the males and females' pupils in the control groups. It can be concluded that the use of ICT tools in the teaching and learning of genetics can act as excellent pedagogical tools that can be used to bridge up gender disparities in genetics and increase performance across gender.

6.2.3. Differences in genetics performance as a function of group name and age group

The study established that the performance of pupils in genetics did not depend on the interaction of group names and age group. Additionally, it was recognised that the use ICTs had an effect on the performance of pupils across group names. The experimental groups out-performed the control group. Furthermore, the use of ICTs had no significant effect on age group and performance of pupils when ICT were used in the teaching and learning of genetics. However, it was established that pupils in the experimental groups performed better than pupils in the control groups despite their age group differences. Finally, it can be concluded that the use of ICTs can help to sort out age-group disparity in pupil's performance in genetics.

6.3.1. Attitudes of pupils and teachers on the use of ICT in the teaching and learning of genetics

The study established that both teachers and pupils had positive attitude towards that use of ICT in the teaching and learning of genetics. Although teachers may have had a positive and high level of attitudes towards, they could not transfer these ICT tools into classroom use for educational purposes due to poor ICT infrastructure, lack of ICT training and technical support from ICT specialists, lack of knowledge and skills. Both teachers and pupils felt that lack of ICT infrastructure, ICT training, CPD, technical support and quality internet in schools perpetuated poor ICT integration in the teaching and learning of genetics.

The study also established that pupils showed a higher degree of ICT knowledge and skills as opposed to teachers who lacked knowledge and skills on the use of ICTs. Despite the challenges teachers and pupils faced, they still held a positive attitude that ICT provided an ideal environment for discussing, sequencing, and explaining abstract concepts of genetics in the teaching and learning of genetics better than traditional teaching-learning methods. They believed that different ICT tools can be used in the teaching and learning of genetics to bring context to life far much better than when using traditional teaching-learning methods. And as such, teachers and pupils purported that ICT provided good experiences for teaching and learning of genetics because of the ICT potential to offer variety of teaching and learning resources.

Accordingly, teachers and pupils contended that ICT increased their motivation, interest, creativity and confidence in the teaching and learning of genetics. Furthermore, teachers and pupils highlighted that ICTs can be excellent pedagogical tool because of multiple facilities they are able to provide better than traditional teaching-learning methods in the teaching and learning of genetics. This meant that the abstractness of genetics concepts could be taught and learned in different multimodalities (visual, text, audio, audio-visual, games and simulations).

Based on the findings, it can be concluded that the use of ICTs in the teaching and learning of genetics develops the positive attitude towards genetics. Additionally, having the right attitude towards ICT and its usage cannot only yield benefits for teachers but also to the pupils. Thus, pupils' and teacher's attitudes towards ICT use are a major enabling and disabling factor in the adoption and integration of ICT in the teaching and learning of genetics. Apart from that, it was concluded that other factors such as teachers and pupils skills and knowledge of ICTs, ICT infrastructure, ICT training and technical support affected their attitudes towards ICT use in the teaching and learning of genetics.

Furthermore, it was established that ICTs were resourceful tools that made pupils and teachers to be more creative, motivated and improved the teaching and learning of genetics through the change in their attitudes towards genetics. Nevertheless, the successful implementation of ICT (educational technologies) depends largely on the attitudes of teachers, who eventually determine how they are used in the classroom activities.

6.4. Recommendations

The following recommendations arose from the research findings, drawn in this study.

i. Biology educationist and curriculum developers should develop a curriculum in biology with specific user friendly ICT pointer tools that can be used in the teaching and learning of genetics. This would help teachers who are not familiar with ICT to implement them in the teaching and learning processes.

ii. Higher educational institutions should train teachers of biology in the use of ICTs in teaching and learning of genetics in schools. These educational institutions should also frame curriculum that are tailored on modern innovative ways of teaching and learning of biology (genetics) using ICT tools so that teachers on training an equipped with ICT knowledge and skills.

iii. Schools and districts administrators should development CPD cycles that integrates ICTs in the teaching and learning of genetics. This is for the purpose of re-training and training teachers with poor ICT skills and knowledge.

iv. The MoGE and other stakeholders in education should equip new and upgraded ICT infrastructure and resources in schools and educational resource centres so that teachers and pupils can use them for research and as pedagogical tools in the teaching and learning of genetics (biology).

v. The MoGE should start providing fast-track ICT training programs that are more feasible and achievable, and that focuses on developing basic ICT literacy skills, which should help pupils and teachers of biology to use ICTs as information sources and work tools.

vi. The MoGE should provide ICT technician (technical support) in schools that can provide guidance to teacher and pupils on the use of ICTs in the teaching and learning of genetics.

6.5. Proposed areas for future research

In view of the findings of the study, it is therefore important to propose some areas for further research.

i. An assessment of teacher's competence in the use of ICTs in the teaching and learning of genetics: An experimental study in Zambian schools.
ii. The use of WhatsApp to support teaching and learning of genetics in some selected secondary schools in Zambia.
iii. An assessment of e-Biology laboratories in some selected secondary schools in Zambia.

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APPENDICES

APPENDIX A: INFORMATION SHEET

Researcher: Chileshe Gregory, School of Education: The University of Zambia.

I am a Masters Student in Education, (Biology Education) at The University of Zambia. The study I am undertaking is investigating the integration of ICT in the teaching and learning of genetics. The University requires that informed consent be obtained from participants.

I am inviting administrators, teachers and learners to participate in this study. Participants will be interviewed face to face, tested and questioned. Should any participants feel the need to withdraw from the study, they may do so without question at any time before the data is analysed. Just let me know at the time.

Responses collected will form the basis of this research study and will be put into a written report on an anonymous basis. It will not be possible for you to be identified personally. Only grouped responses will be presented in this report. All material collected will be kept confidential. No other person besides me and my supervisor, Dr, K Nachiyunde will see the raw data. The thesis will be submitted for marking to the School of Education and deposited in the University of Zambia repository Library. It is intended that one or more articles based on the information obtained will be submitted for publication in scholarly journals.

If you have any questions or would like to receive further information about the study, please contact me on +260976-244-911 or my supervisor, Dr, K Nachiyunde, at the School of Education (MSE department), The University of Zambia, P.O Box 32379, Lusaka.

Chileshe Gregory

Signed: ....

APPENDIX B: INFORMED CONSENT TO PARTICIPATE IN RESEARCH-TEACHER

My name is Mr. Chileshe Gregory. I am from The University of Zambia, Great East. Road Campus. From the Department of Mathematics and Science Education (MSE).

Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate. We are asking you to take part in the research study because we are trying to learn about your attitudes towards that the integration of ICT in the teaching and learning of genetics.

1. There are no risks in taking part in this study. Taking part in the study will make you a contributor to the possible improvement of how RE is taught and learnt.
2. If you do not want to be in this study, you do not have to participate. Remember, being in this study is up to you and no one will be upset if you do not want to participate or even if you change your mind later and want to stop.
3. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me on +260976-244-911 or ask me next time.
4. Signing your name at the bottom means that you agree to be in this study.

Name and signature of participant Date:

....

APPENDIX C: INFORMED CONSENT TO PARTICIPATE IN RESEARCH-PUPIL

My name is Mr. Chileshe Gregory. I am from The University of Zambia, Great East

Road Campus. From the Department of Mathematics and Science Education (MSE). Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate. We are asking you to take part in the research study because we are trying to learn about your performance and attitude towards the integration of ICT in the teaching and learning of genetics.

1. If you agree to be in this study, we shall ask you questions about well you know genetics. There are no risks in taking part in this study.
2. Taking part in the study will make you a contributor to the possible improvement of how genetics is taught and learnt.
3. Please talk this over with your parents before you decide whether or not to participate.
4. If you do not want to be in this study, you do not have to participate. Remember, being in this study is up to you and no one will be upset if you do not want to participate or even if you change your mind later and want to stop.
5. You can ask any questions that you have about the study. If you have a question later that you didn't think of now, you can call me on +260976-244-911 or ask me next time.
6. Signing your name at the bottom means that you agree to be in this study.

____

Name and signature of participant

Date: ____

APPENDIX D: FACE TO FACE INTERVIEW GUIDE FOR TEACHERS OF BIOLOGY

Interviewer: ______________________________

Interviewee: ______________________School: ________________. Date: __________

Place: ___________________________Start Time: _____________ Archival #: ______

Please note that this is a purely academic study which seeks to investigate teachers' attitude in the use of ICT tools in the teaching and learning of genetics. The information that will be collected will not be used against you in any way.

1. What is the extent to which ICTs are used in teaching biology lessons?
2. What kinds of ICTs facilities are available in your school?
3. Do you as a school have any ICT training programme for teachers and pupils?
4. Do you have a particular teacher in charge of ICTs in your school?
5. Do teachers use ICTs in their teaching of genetics?
6. Do you use ICTs across the school curriculum?
7. In your view, are some school subjects better suited for use of ICTs compared to the teaching and learning of genetics? If yes, which subjects?
8. What benefits do you think come with the use of ICTs in teaching genetics?
9. What is your view about the use of ICTs in teaching and learning of genetics?
10. Is there anything else you would like to share regarding the role of ICTs in teaching?
11. How would you describe the attitude of teachers of biology towards the use of ICTs?

End Time: ________________

Thank you for your time and participation in this study

APPENDIX E: FOCUS GROUP INTERVIEW GUIDE FOR PUPILS/LEARNERS

Interviewer:_________________________

Interviewee:___________________School:_________________.Date:___________

Place: ________________________Start Time: ____________Archival #:_________

Please note that this is a purely academic study which seeks to investigate learners'' attitude in the use of ICT tools in the learning of genetics. The information that will be collected will not be used against you in any way.

1. What ICT tools are you familiar with?
2. What ICTs facilities do you have in your school?
3. Does the school teach you how to use ICTs?
4. Do you have access to ICTs in school and at home?
   If Yes, how do you used these ICT tools in learning of genetics?
5. Do you or some of your friends in school come with ICTs to school?
   If yes, how do they use the ICTs for learning of genetics?
6. Does your genetics teacher teach using any of the ICTs facilities in your lessons? If yes, explain.
7. What ICTs do you think should be used in genetics lessons? Why?
8. Do ICTs improve learning in genetics?
9. Do other teachers in other subjects use ICTs? Give examples.
10. How often do you use ICTs in genetics compared to other topics in biology?
11. When ICTs are used in genetics, do you understand the lessons better or not? Explain.
12. How often do you use ICTs in genetics projects, exercises or homework? Explain.

End Time: ______________________

Thank you for your time and participation in this study.

APPENDIX F: TEACHERS' ATTITUDE QUESTIONNAIRE

Please note that this is a purely academic study which seeks to investigate teachers' attitude in the use of ICT tools in the learning of genetics. The information that will be collected will not be used against you in any way.

1. Demographic
   a) Gender: **Male** ☐ **Female** ☐
   b) Age: ☐
   c) Class: ☐
2. How long have you worked as a teacher of biology? ☐
3. **Put a tick () in the appropriate box that suits your response to the given statement**

S/N	ITEMS	6	5	4	3	2	1
1	I believe the use of ICT tools in teaching is an interesting experience						
2	I understand the abstract concepts of genetics can be explained and understood better by the use of ICT tools in teaching than the traditional classroom presentation						
3	Use of ICT tools allows one to discuss genetics with others much more than the traditional approach method						
4	The use of ICT tools in teaching can increase the levels of motivation in genetics						
5	The information on all the lessons on genetics can be made more clear through the use of IC tools.						

6	The use of ICT tools in teaching can add quality to the materials for genetics compared to what would normally be covered in a normal traditional classroom.						
7	The use of ICT tools in teaching can increased my degree of interest in genetics and biology.						
8	The ICT tools allowed me to understand complicated concepts in genetics better						
9	The use of ICT offers me an ideal environment for learning and sequencing various ideas on each genetics subtopic than traditional methods.						
10	The use of ICT in genetics can provide for more creativity in planning and teaching of genetics.						
11	I can teach more things about genetics through the use of ICT than I teach using Traditional methods.						
12	I would like that genetics be taught with the use of ICT tool than using Traditional methods only.						
13	I would like the Traditional method of learning genetics be replaced completed with the use ICT tools in the teaching and learning rather than only supplementing it.						

14	I recommend the use of the ICT tools in the learning of genetics and other topics in Biology.						

Key

6. strongly agree. **5. Moderately agree.** **4. Slightly agree.**

3. Slightly disagree. **2. Moderately disagree.** **1. Strongly disagree**

Thank you for your time and participation in this study.

APPENDIX G: PUPILS' ATTITUDE QUESTIONNAIRE

Please note that this is a purely academic study which seeks to investigate pupils' attitude in the use of ICT tools in the learning of genetics. The information that will be collected will not be used against you in any way.

1. Demographic
   a) Gender: **Male** ☐ **Female** ☐
   b) Age: ☐
   c) Class: ☐

2. Put a tick () in the appropriate box that suits your response to the given statement

S/N	ITEMS	6	5	4	3	2	1
1	The use of ICT tools was an interesting experience						
2	In understanding the concepts of genetics, the use of ICT tools is better than the traditional classroom presentation						
3	Use of ICT tools allows one to discuss genetics with others much more that the traditional approach method						
4	My level of motivation on genetics has increased with the use of ICT tools						
5	The information on all the lessons on ICT tools was clear.						

6	The amount and quality of material in the use of ICT tools were just about the right compared to what would normally be covered in a normal traditional classroom						
7	The use of ICT tools has increased my degree of interest in genetics and biology						
8	The ICT tools allowed me to understand complicated concepts in genetics better						
9	The use of ICT offered me an ideal environment for learning and sequencing various ideas on each lesson than traditional methods.						
10	The use of ICT in genetics made me more creative						
11	I have learnt more things about genetics through the use of ICT than I learned using Traditional methods.						
12	I would like that genetics be taught with the use of ICT tool than using Traditional methods only.						
13	I would like the Traditional method of learning genetics be replaced completed with the use ICT tools in the teaching and learning rather than only supplementing it.						

14	I recommend the use of the ICT tools in the learning of genetics and other topics in Biology.						

Key

6. strongly agree. **5. Moderately agree.** **4. Slightly agree.**

3. Slightly disagree. **2. Moderately disagree.** **1. Strongly disagree**

Thank you for your time and participation in this study.

APPENDIX H: GENETICS PRE-TEST AND POST-TEST

Duration: 25 minutes

INSTRUCTIONS TO CANDIDATES

Do not write your name or identity on any of this paper.

There are two sections in this paper: section A and section B.

There are ten questions in section A. Answer all questions. For each question, there are fourteen possible answers genetic terminologies. Choose the one you consider correct and record, a letter on the space provided as your choice in pen on the same question sheet.

There are ten questions in section B. Answer all questions. For each question, there are four possible answers, A, B, C and D. Choose the one you consider correct and record your choice in pen on the same question sheet.

INFORMATION FOR CANDIDATES

Each correct answer in section A will score one and half (1/2) mark.

Each correct answer in section B will score one mark.

A mark will not be deducted for a wrong answer. Any rough working should be done on the extra paper that you have been provided with.

No scientific calculators or any material related to this subject is allowed.

No phones or electronic devices is allowed.

Section A

You are provided with different terminologies that are used in genetics. Write a **letter** on the space provided that fits the correct terminology for each statement below.

A. Recessive gene. **B.** Continuous variation **C.** Allele **D.** Mutation

E. Gene **F.** Locus **G.** Homologous **H.** Chromosomes

I. Heterozygous **J.** Phenotype **K.** Discontinuous variation **L.** Genotype

M. Variations **L.** Variation.

1. **...:** These are thread-like structure found in the nucleus of all cells.
2. **...:** This is the alternative form of the gene.
3. **...:** These are characteristics which have no intermediates forms, that is, individuals show a clear–cut differences among themselves.
4. **...:** This is the position of the gene on a chromosome.
5. **...:** This is a unit of inheritance.
6. **...**: This means that a pair of the same genes.
7. **...:** This means a pair of different genes.
8. **...:** This is a gene which in presence of its contrasting allele does not show or express itself.
9. **...:** This refers to the external appearance of an organism.
10. **...:** This is the genetic make-up of an organism.

Section B

Circle the **only one** corrected answer.

1. Which of these may be heterozygous?
   A. a haploid cell
   B. an allele of a gene
   C. an organism with a dominant phenotype
   D. an organism with a recessive genotype

2. Flower colour is controlled by a single pair of alleles. The allele for red flowers is dominant to the allele for white flowers. A plant homozygous for red flowers is crossed with a plant homozygous for white flowers. All the resulting plants have red flowers (F1 generation). When the F1 generation are crossed with each other, 18 plants are obtained. 12 plants have red flowers and 6 have white flowers (F2 generation).

What ratio is expected in the F2 generation and what ratio has been obtained?

expected ratio red to white   Observed ratio red to white

	Expected ratio red to white	Observed ratio red to white
A	1: 1	2:1
B	1:	3:1
C	3:1	2:1
D	3:1	3:1

3. Which statement about sperm cells is correct?
   A. They contain either one X or one Y chromosome.
   B. They contain one X chromosome.
   C. They contain one Y chromosome.
   D. They contain two X chromosomes.
4. A variety of snail has an inherited condition that affects the thickness of the shell.

   S^t S^t have thick shells.

   S^t S^n have thin shells.

   S^n S^n do not survive.

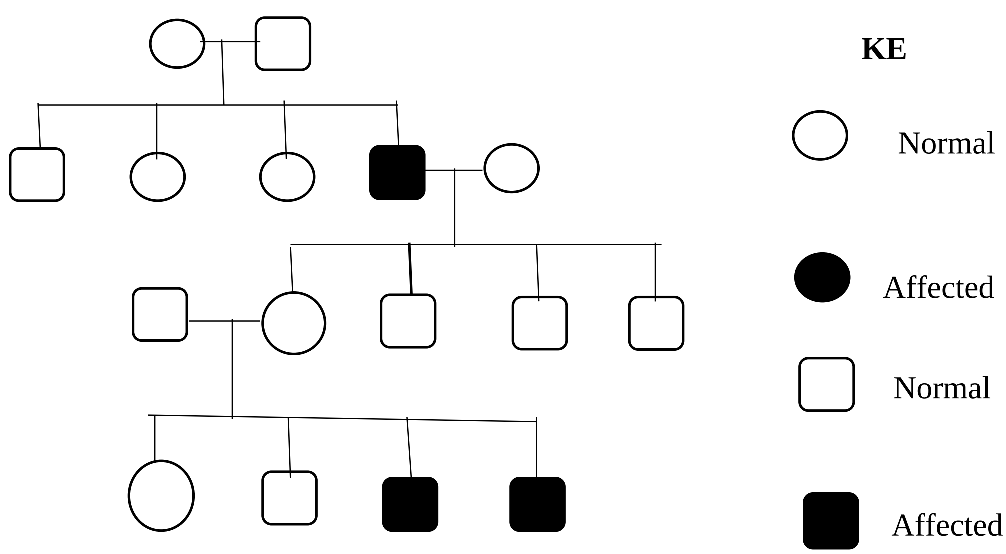
   Two heterozygous snails are mated.

   What is the probability that a surviving snail of the next generation is a heterozygote?

   A. 0.00
   B. 0.25
   C. 0.50

D. 0.67

5. A pure breeding black mice is mate with a brown female mouse and they produce 12 offsprings. If the allele for the black fur is dominant to the allele for brown fur. what would be one possible distribution of fur colour?
   A. 6 brown females and 6 black males
   B. 9 brown females and 3 black males
   C. 12 brown females
   D. 12 black males
6. The family pedigree below shows the pattern of inheritance of genetic disease caused by a sex-linked gene.



What conclusion can be drawn from the diagram?

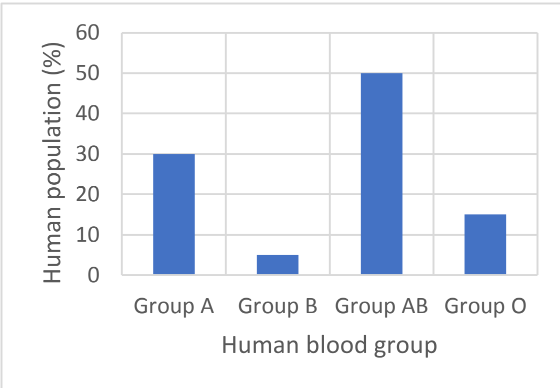
   A. Both males and females are carriers
   B. Only females are carriers
   C. Only males are carriers
   D. There are no carriers in the pedigree
7. In rabbits, the allele for brown coat (B) is dominant to the allele for the allele for white coat (b). what is the chance/ probability that the offspring will be white when a homozygous brown rabbit is mated with a white rabbit?
   A. 0%

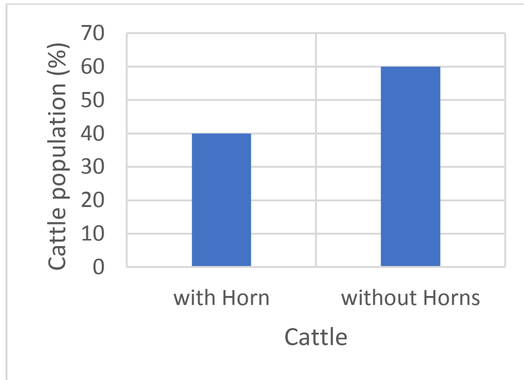
B. 25%

C. 75%

D. 100%

8. The bar charts show the percentages of a human population with each type of blood group and the percentages of a cattle population with and without horns.





Which type of variation is shown in each population?

	humans	Cattle
A	Continuous	Continuous
B	Continuous	Discontinuous
C	Discontinuous	Continuous
D	Discontinuous	Discontinuous

9. A pregnant woman is told by a genetics counselor that her baby has an equal chance of being blood group A and AB. What is the possible genotype of the baby?

A. AA and BO

B. AB and BO

C. AO and BB

D. AB and AO

10. Sickle- cell anaemia is caused by a rare spontaneous change on a gene called

A. Substitution mutation

B. Addition mutation

C. Disjoint mutation

D. Elimination mutation

Good luck and all the best

Thank you for your time and participation in this study.